

GEORGE G. BOGREN

JOURNAL OF THE
BOSTON SOCIETY
OF
CIVIL ENGINEERS



APRIL - 1936

VOLUME XXIII

NUMBER 2

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Published four times a year, January, April, July and October, by the Society
715 Tremont Temple, Boston, Massachusetts

Subscription Price, \$4.00 a Year (4 Copies)
\$1.00 a Copy

Copyright, 1936, by the Boston Society of Civil Engineers.
Entered as second-class matter, January 15, 1914, at the Post Office
at Boston, Mass., under Act of August 24, 1912.

Acceptance for mailing at special rate of postage provided for in
Section 1103, Act of October 3, 1917, authorized on July 16, 1918.

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BOSTON
WRIGHT & POTTER PRINTING COMPANY
32 DERNE STREET

JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

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THE DESIGN OF STATICALLY INDETERMINATE TRUSSES

BY ALBERT HAERTLEIN, MEMBER*

(Presented at a meeting of the Designers Section of the Boston Society of Civil Engineers,
held on January 8, 1936)

DURING the past decade statically indeterminate trusses have been built with increasing frequency in spite of the laborious calculations and of the assumptions used in making the preliminary design, which have often discouraged engineers from using this type of structure. The calculating machine has greatly lessened the labor of computing. It is the purpose of this paper to demonstrate a method of obtaining a preliminary design which will approximate the final design without introducing assumptions which are now generally made.

Trusses are statically indeterminate when either the reactions or the stresses cannot be found by the application only of the laws of statics. A continuous truss, having more than two supports, and the two-hinged framed arch are examples of structures whose reactions cannot be determined by the equations of statics alone. Multiple web system trusses, such as the Whipple or double Warren types, are examples of trusses whose stresses cannot be found by statics alone, even though the loads and the reactions are known. This paper will confine itself to those trusses in which the reactions are statically indeterminate.

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Whenever the number of unknown quantities concerning the reactions is greater than the equations of statics (three for the case of all forces lying in a plane), then additional independent equations must be found to make a solution possible. A continuous truss having each reaction pass through a pin, and all, except one, on rollers, will have $(n+1)$ unknowns where n =number of supports. Therefore any truss continuous over more than two supports is statically indeterminate. A two-hinged arch will have the direction and magnitude of each of the two reactions unknown, so that there will be four unknowns with only three independent equations from statics.

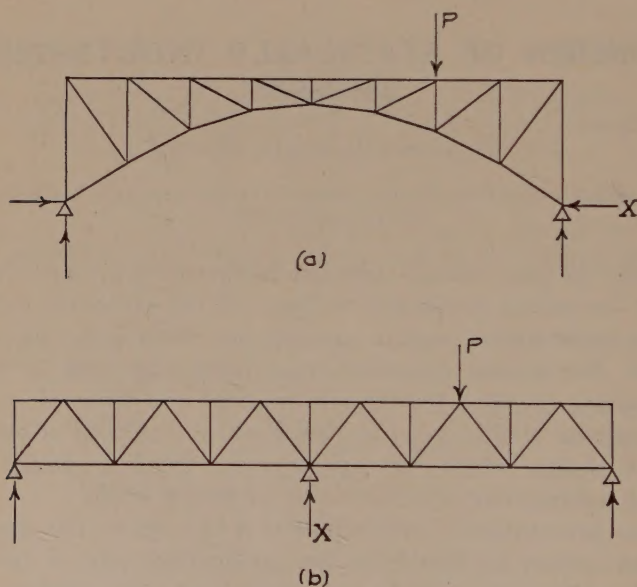


FIG. 1

Additional equations are supplied by taking into consideration the elastic characteristics of the frame. Two methods are in common use. The one is based on the principle of *least work*, and the other is based on the principle of *virtual work*. These two methods can be illustrated for finding X for a two-hinged framed arch and a continuous truss over three supports as shown in Fig. 1 for the case of vertical loads.

Let s = stress in each member due to the vertical loads and the vertical reactions caused by these loads without including the stress due to force X .

t = stress in each member due to a unit force applied at the point where the force X is applied and in the direction of X , divided by the unit force.

A = area of cross section of each member.

L = length of each member.

E = modulus of elasticity of each member.

Then Xt = stress in each member due to force X .

By the method of least work an expression is written for the total internal work or total external work (being equal to each other), thus:

$$\text{Total internal work} = W = \sum \frac{(s + Xt)}{2} \cdot \frac{(s + Xt)L}{AE}, \text{ the summation}$$

being for all the members of the truss; or

$$W = \sum \frac{s^2 L}{2AE} + X \sum \frac{stL}{AE} + \frac{X^2}{2} \sum \frac{t^2 L}{AE}$$

To find the minimum, differentiate with respect to X and set $\frac{dW}{dX}$ equal to zero, or

$$\frac{dW}{dX} = \sum \frac{stL}{AE} + X \sum \frac{t^2 L}{AE} = 0$$

from which

$$X = - \frac{\sum \frac{stL}{AE}}{\sum \frac{t^2 L}{AE}}$$

When all members are made of material having the same modulus of elasticity, E , the expression reduces to —

$$X = - \frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}}$$

By the principle of virtual work, the movement of any point is equal to $\sum \frac{stL}{AE}$

where s = stress in each member due to actual loads.

t = stress in each member due to a unit load applied at the point and in the direction where the movement is to be found, divided by the unit load.

If the structure be made statically determinate by placing the right support of the two-hinged arch on rollers and by removing the center support of the continuous truss, this expression enables one to find the horizontal movement to the left of B or the upward vertical movement of C due to the actual loads. The value of s will be the same as in the preceding illustration.

The horizontal movement at B or the vertical movement at C due to X must be such that the resultant movement is zero. This can be expressed as follows:

$$\sum \frac{stL}{AE} + X \sum \frac{t^2 L}{AE} = 0$$

$$X = - \frac{\sum \frac{stL}{AE}}{\sum \frac{t^2 L}{AE}}$$

If E is the same for all members, the value of

$$X = - \frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}}$$

It is observed that both principles give identical final expressions for the force X . The problem for the designer is to find the value of X for any condition of loading, so as to be able to find the maximum stress in each member for the purpose of selecting its size and shape. The influence table or diagram is useful for finding the position of loads to cause the maximum effects. The values in the table or ordinates in the diagram give the value of a function, such as stress in a member,

for a single load of unity placed at a definite point, base of ordinate. To find the stress in a member, the structure is cut into two separate parts, including a cut through the member whose stress is desired. If the structure as a whole is in equilibrium, then either part must be in equilibrium under the action of the loads, reactions and stresses in the cut members. Consequently, the equations of statics may be applied to the forces acting on either part of the structure. One or more of the forces on either side of the section may involve X . Hence it becomes necessary to find the value of X for various positions of the unit load or to prepare an influence table or diagram for X .

$$\text{Since } X = - \frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}}, \text{ it is evident that before } X \text{ can be found from}$$

this expression it is necessary to know the area of each member. Since the area is what ultimately is desired, a dilemma confronts the designer. In order to find the area, the area needs to be known before it can be found. The procedure outlined in textbooks, other literature and office practice with which the writer is familiar, requires that a preliminary design be made in some manner, generally by assuming the structure to be something different from what it is; or some designers and authors for their first trial assume all of the areas equal. For continuous trusses, a preliminary design is generally made on the basis of a continuous beam of constant moment of inertia; and, by applying Clapeyron's Three Moment equation, the reactions are readily found. For the framed arches the horizontal components of the reactions are found by using an approximate formula for the determination of the horizontal component of a solid parabolic arch. Having thus found an approximate area, the true value of X can be found from the foregoing expression. From this the maximum stress in each member can be determined and a new area found. If the preliminary sections are too much in error (as usually happens), the whole process is repeated with the revised areas until the final calculated areas agree reasonably well with the values of the areas used in getting them. Hence it is evident that the crux in the solution of these statically indeterminate frames is in guessing at the areas used in the calculations to find the areas. The labor involved in making such calculations is indeed very great, since the summation of these products for all bars is involved. A truss with a hundred or more bars is not uncommon.

The purpose of this paper is to show that the design can be made without making a preliminary design based on assuming the truss to be a beam and using approximate expressions. It is desired to show that $\frac{\sum s}{\sum t}$ gives a reasonably close value of X , which may be used for finding stresses in the members and hence the areas. Having thus found the areas, X can be found from the more elaborate equation and some slight revisions in the design may then appear desirable.

The final expression $X = - \frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}}$ may be built up from the simple

expression $\frac{\sum s}{\sum t}$, first by multiplying each term by its t value, thus

getting $\frac{\sum st}{\sum t^2}$; then multiplying each term by its length, L , thus getting

$\frac{\sum stL}{\sum t^2 L}$; and finally multiplying by its $\frac{1}{A}$, resulting in the final expression

$\frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}}$. So that the problem is to get some idea of the magnitude of

the difference between $\frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}}$ and $\frac{\sum s}{\sum t}$, or $\frac{\sum st}{\sum t^2}$ or $\frac{\sum stL}{\sum t^2 L}$.

Expressed in another way, it is to find the value of

$$\frac{\sum sk}{\sum tk} - \frac{\sum s}{\sum t}$$

where k may be t , L , A or combinations of these.

A cursory examination of these series will show that

$$\frac{s_1 k_1 + s_2 k_2 + s_3 k_3 + \dots s_n k_n}{t_1 k_1 + t_2 k_2 + t_3 k_3 + \dots t_n k_n} - \frac{s_1 + s_2 + s_3 + \dots s_n}{t_1 + t_2 + t_3 + \dots t_n}$$

will be zero when $k_1=k_2=k_3=\dots k_n$, because then k can be factored from each term in the numerator and the denominator and be cancelled. It can also be demonstrated that the difference is zero when

$$\frac{s_1}{t_1} = \frac{s_2}{t_2} = \frac{s_3}{t_3} = \dots \frac{s_n}{t_n}$$

A numerical example will illustrate the last case. Consider any series, such as —

$$\frac{1+2+3+4}{2+4+6+8} = \frac{10}{20} = 0.5$$

$$\text{Take } k_1=2, k_2=5, k_3=4, k_4=3$$

$$\text{Then } \frac{1 \times 2 + 2 \times 5 + 3 \times 4 + 4 \times 3}{2 \times 2 + 4 \times 5 + 6 \times 4 + 8 \times 3} = \frac{2+10+12+12}{4+20+24+24} = \frac{36}{72} = 0.5$$

When the corresponding terms in the numerator and the denominator do not bear a constant ratio to each other, then the value of the fraction will have for its limits the value of the least ratio and the value of the greatest ratio. For example —

$$\frac{1+2+3+4}{2+3+4+5} = \frac{10}{14} = 0.714$$

When $k_1=2, k_2=5, k_3=4$ and $k_4=3$ as before, then

$$\frac{2+10+12+12}{4+15+16+15} = \frac{36}{50} = 0.720$$

When $k_1=20, k_2=5, k_3=4$ and $k_4=3$, then

$$\frac{20+10+12+12}{40+15+16+15} = \frac{54}{86} = 0.628$$

When $k_1=200, k_2=5, k_3=4$ and $k_4=3$, then

$$\frac{200+10+12+12}{400+15+16+15} = \frac{234}{446} = 0.525$$

When $k_1=2, k_2=5, k_3=4$ and $k_4=30$, then

$$\frac{2+10+12+120}{4+15+16+150} = \frac{144}{185} = 0.778$$

When $k_1=2$, $k_2=5$, $k_3=4$ and $k_4=300$, then

$$\frac{2+10+12+1200}{4+15+16+1500} = \frac{1224}{1535} = 0.797$$

Just where the result will lie between the limits of the least and greatest ratios depends on the relative magnitudes of the multipliers. From the above examples, it appears to lie near the ratio having the largest multiplier.

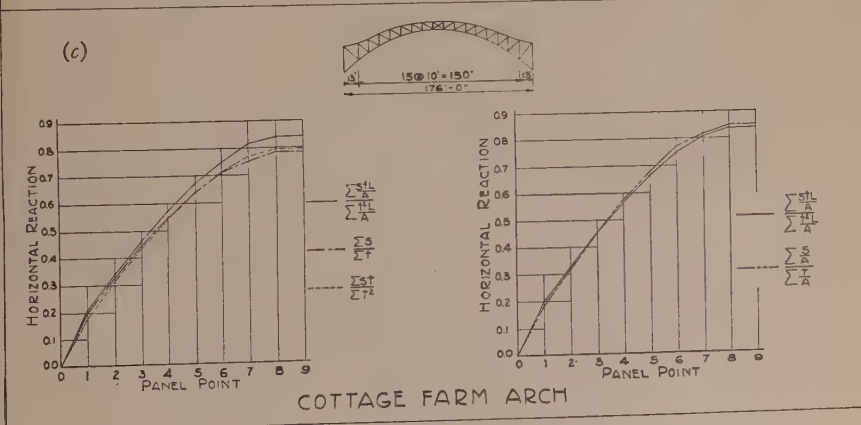
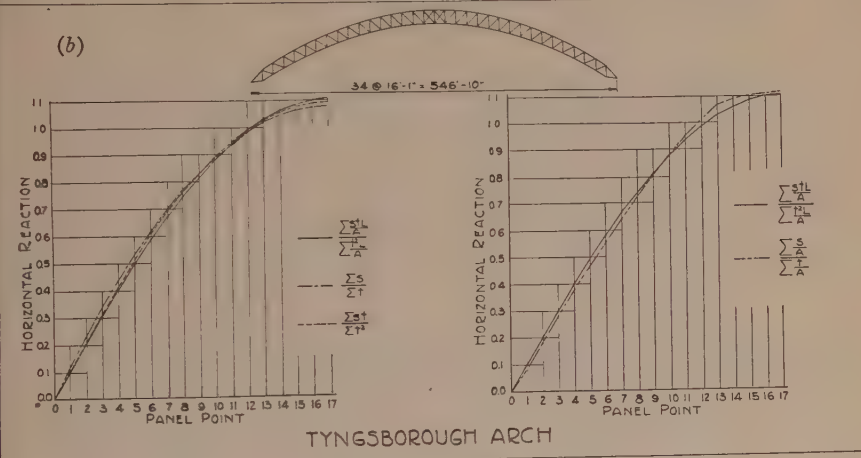
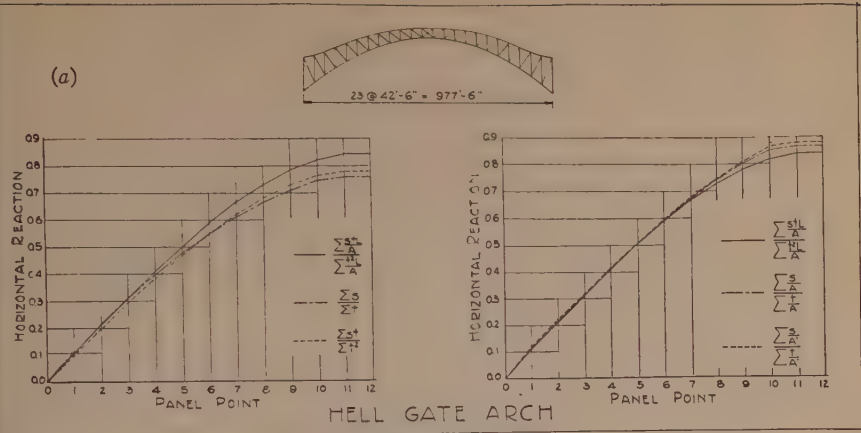
These relationships of fractions with series in the numerator and the denominator are interesting indeed, but what is their application for finding the value of X ? If

$$\frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}} = \frac{\sum s}{\sum t}$$

it would follow that the horizontal component of the reaction in a two-hinged framed arch or the vertical reaction in a continuous truss was independent of the cross-section areas of the members and independent of the lengths of the members in so far as summations involving L directly are concerned. Actually X is dependent on the length of the members because the lengths determine the values of s and t .

Several years ago an investigation was begun by Mr. Lee H. Johnson, a graduate student at the Harvard Graduate School of Engineering, under the direction of the writer, to study these relationships in several structures which had been built, or were about to be built, and for which the design data could be obtained. Complete studies were made of the Hell Gate, Tyngsborough and Cottage Farm two-hinged arches and the Greenfield-Montague continuous truss in the western part of Massachusetts. It was believed that these represented typical structures of various designs and with various types of loading. For each of these bridges an influence table for X was prepared on each of the following bases:

$$X = \frac{\sum s}{\sum t}; \quad X = \frac{\sum st}{\sum t^2}; \quad X = \frac{\sum \frac{stL}{A}}{\sum \frac{t^2 L}{A}}$$



INFLUENCE LINES FOR HORIZONTAL REACTION

FIG. 2

and for the arches on the basis that —

$$X = \frac{\sum \frac{s}{A}}{\sum \frac{t}{A}}$$

and for the continuous truss that —

$$X = \frac{\sum \frac{st}{A}}{\sum \frac{t^2}{A}}$$

The influence diagrams indicate a remarkably close agreement of the values of X as obtained from the several equations as shown in Figs. 2 and 3 (a). A detailed study of these influence lines showed that the terms in the series could be assembled into four distinct groups, namely, top chord, bottom chord, diagonals and verticals. It also showed that the web members had but a small effect on the value of X as shown by the following table:

AVERAGE ERROR IN PER CENT DUE TO IGNORING WEB MEMBERS

	$\frac{\sum s}{\sum t}$	$\frac{\sum st}{\sum t^2}$	$\frac{\sum stL}{\sum t^2L}$	$\frac{\sum \frac{stL}{A}}{\sum \frac{t^2L}{A}}$
Hell Gate arch	3.02	0.54	0.92	1.35
Tyngsborough arch . . .	1.85	0.07	0.19	0.57
Cottage Farm arch . . .	3.78	1.02	1.30	3.10

The average error is obtained by multiplying the per cent error for each ordinate, introduced by omitting the web members, by the magnitude of the ordinate itself. Dividing the sum of these weighted per cent errors by the sum of the ordinates gives the weighted average error.

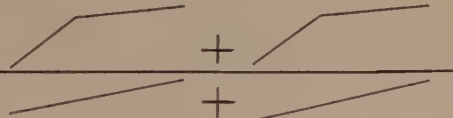
Hence further study of the series was restricted to the two groups, namely, the top and bottom chord members. For a series in which

$\frac{s_1}{t_1} = \frac{s_2}{t_2} = \frac{s_3}{t_3} = \frac{s_n}{t_n}$, a graphical representation of the s values and the t

values would be a straight line for each, such as

$$\begin{array}{l} s \text{ values} \\ t \text{ values} \end{array} \quad \frac{\sum s}{\sum t} = \frac{\text{---}}{\text{---}}$$


The s values for a double vertical unit loading, symmetrically placed, and the t values for top and bottom chords of the structures investigated may be represented by the following curves:

$$\begin{array}{l} s \text{ values} \\ t \text{ values} \end{array} \quad \frac{\sum s}{\sum t} = \frac{\text{---}}{\text{---}} + \frac{\text{---}}{\text{---}}$$


The t values lie approximately on two straight lines, one for each chord. These lines represent the stress in the chord members due to a unit load at the reaction divided by the unit load. The s values for each chord lie on two approximately straight lines of different slope. The reason for the change of slope is due to the sudden change in the moment diagram. A mathematical expression giving the difference between two successive ratios where two sets of s values form broken lines shows that the difference is not only dependent on the difference between multipliers of the same group but also on the difference between the multipliers of the two groups. This explains the reason for the rela-

tively small difference between $\frac{\sum s}{\sum t}$ and $\frac{\sum st}{\sum t^2}$; also between $\frac{\sum st}{\sum t^2}$ and $\frac{\sum stL}{\sum t^2L}$. It follows that in an arch the influence values for X will be

about the same whether they are calculated from $\frac{\sum s}{\sum t}$, $\frac{\sum st}{\sum t^2}$ or $\frac{\sum stL}{\sum t^2L}$.

The difference in the influence values so calculated and those which are

calculated from $\frac{\sum \frac{stL}{A}}{\sum \frac{t^2L}{A}}$ will depend on the relative size of the top and

bottom chord members. If these are approximately of the same size as in the Tyngsborough arch, all four ratios will give approximately the same influence line for X .

For continuous trusses with parallel chords where the s values may be represented by a sloping line and a horizontal line for each chord,

the largest difference occurred between $\frac{\Sigma s}{\Sigma t}$ and $\frac{\Sigma st}{\Sigma t^2}$. It is therefore recommended for such structures that the first influence table or diagram for X be obtained from $X = \frac{\Sigma st}{\Sigma t^2}$.

In conclusion, the following procedure for design of statically indeterminate structures is recommended:

1. For arches, determine the influence table or diagram for the horizontal component of the reaction from the expression $X = \frac{\Sigma s}{\Sigma t}$.

Then determine the influence table or influence line for each member. Find the maximum stress and design the cross section of each member. With these areas calculate a new influence table or diagram for X , using either

$$X = \frac{\Sigma \frac{s}{A}}{\Sigma \frac{t}{A}} \quad \text{or} \quad \frac{\Sigma \frac{stL}{A}}{\Sigma \frac{t^2L}{A}}$$

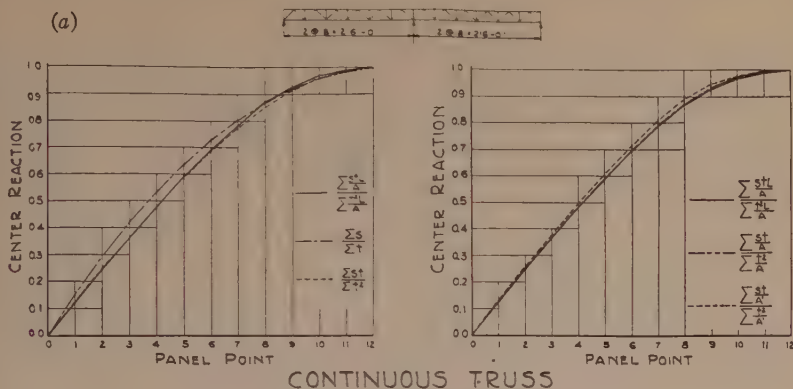
This second set will closely approximate the final set, which will generally require little or no modification.

2. For continuous trusses with curved chords, follow the same procedure as for arches.

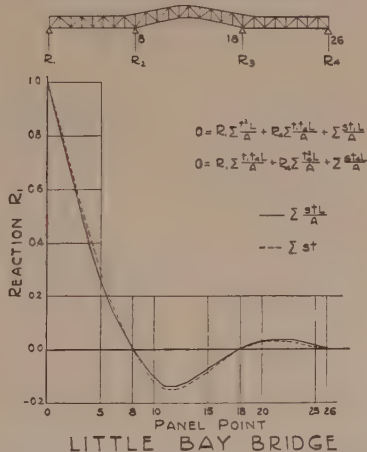
3. For continuous trusses with parallel chords, make the first design from $X = \frac{\Sigma st}{\Sigma t^2}$, and the second from

$$X = \frac{\Sigma \frac{st}{A}}{\Sigma \frac{t^2}{A}} \quad \text{or} \quad \frac{\Sigma \frac{stL}{A}}{\Sigma \frac{t^2L}{A}}$$

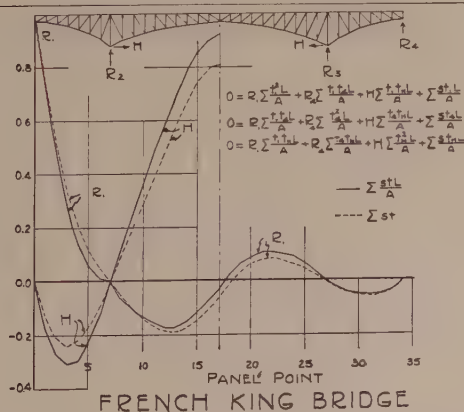
(a)



(b)



(c)



INFLUENCE LINES FOR REACTIONS

FIG. 3

The method has also been applied to trusses in which the number of reaction components was more than one greater than the equations of statics. Fig. 3 (*b*) and 3 (*c*) show influence lines for two such cases. It is evident that the agreement between the lines is such that good approximations are obtained by ignoring the length and the area of the members.

The merit of this procedure lies in the fact that it does not require making a preliminary design for the truss on the basis of finding the reactions as if the truss were a beam. It utilizes only the dimensions of the geometrical outline of the truss, and the terms used in the first approximation are also used in the final determination.

A FUNDAMENTAL FALLACY IN EARTH PRESSURE COMPUTATIONS

BY DR. KARL TERZAGHI, MEMBER *

(To be presented at a meeting of the Boston Society of Civil Engineers on May 20, 1936)

FOR more than a century engineering textbooks have maintained that the pressure of sand on the back of a lateral support increases like a hydrostatic pressure in direct proportion to depth. This hydrostatic pressure distribution is supposed to exist regardless of whether the sand is retained by a masonry wall or by timbering. On the other hand, many engineers and contractors with broad experience in subway construction claim that the distribution of the lateral pressure on the timbering of cuts has no resemblance to the theoretical distribution. This attitude is based on the results of observations such as those which were described in the papers of Mr. J. C. Meem, "The Bracing of Trenches and Tunnels" (Trans. Am. Soc. C. E., Vol. LX, June, 1908), of Mr. H. G. Moulton, "Earth and Rock Pressures" (Trans. Am. Soc. of Min. and Metall. Eng., 1920), and in the discussions of these papers. In the following analysis the causes of these contradictions will be investigated.

RANKINE'S THEORY AND THE NATURAL STATE OF STRESS IN SANDS.

All the customary methods of earth pressure computation can be traced back either to Coulomb's or to Rankine's theory of earth pressure. Since Rankine's theory covers a broader field of application, it may be considered first.

According to Rankine's theory a negligible displacement should suffice to produce a failure by shear in sands. This means that every deposit of sand can be assumed to exist at the verge of the breakdown of its equilibrium. Taking this assumption for granted, an application of the accepted laws of applied mechanics to the state of stress in a mass of sand with an infinite horizontal surface leads to the following conclusions. In every point of such a mass the ratio between the horizontal and the vertical pressure is a constant, equal to —

$$K_r = \tan^2 \left(45 - \frac{\phi}{2} \right)$$

* Visiting Professor at the Graduate School of Engineering, Harvard University, Cambridge, Mass.

wherein ϕ is the angle of repose. The corresponding state of stress will briefly be called the *Rankine state of stress*. The value K_r represents the ratio between the lateral pressure in the sand and the lateral pressure in a liquid whose unit weight is equal to that of the sand. At the same time, K_r represents the smallest value which K can possibly assume in a mass of sand with an infinite horizontal surface. Therefore K_r is called the *minimum* hydrostatic pressure ratio. The index r indicates that it refers to the Rankine state of stress. Since the vertical pressure increases in simple proportion to the depth below the surface, and since, in addition, K_r is a constant, the pressure on any plane section through the sand increases like a hydrostatic pressure in direct proportion to

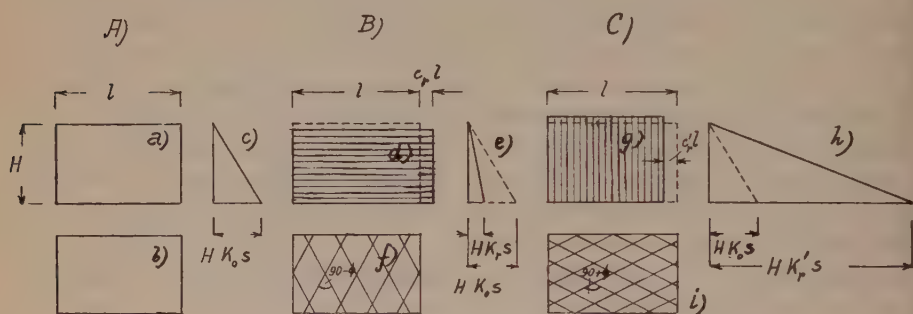


FIG. 1

Three states of stress in sand involving hydrostatic distribution of pressure along plane sections. A=natural state, B=Rankine state for minimum and C=Rankine state for maximum lateral pressure. Diagrams d and g show the deformation required to induce transition from state A into states B and C respectively; diagrams e and h represent the corresponding change of lateral pressure on vertical sections, and f and i show the two sets of planes of shear.

depth, as shown in Fig. 1e. A very small lateral displacement in the sand should suffice to induce failure by shear along two sets of inclined shearing planes rising at an angle of $45 + \frac{\phi}{2}$ to the horizontal. These two sets are shown in Fig. 1f. Since the horizontal displacement is supposed to have no effect other than to induce the slip, the factor "strain" does not appear in the theory.

Again, according to Rankine's theory, a negligible lateral compres-

sion should suffice to increase the hydrostatic pressure ratio throughout the mass of sand from K_r to —

$$K'_r = \tan^2 \left(45 + \frac{\phi}{2} \right)$$

Any further lateral compression induces sliding along two sets of planes rising at an angle of $45 - \frac{\phi}{2}$ to the horizontal, while the hydrostatic pressure ratio K'_r remains unaltered.

In order to find out whether Rankine's assumptions are justified, we first determine the state of stress in a horizontal layer of sand after deposition, either by natural processes of sedimentation or otherwise. Then we investigate the means by which this state may be changed into either one of the two Rankine states of stress, indicated by the diagrams under the letters *B* and *C* in Fig. 1.

If a bed of sand is formed by sedimentation or by some artificial procedure the area covered by the individual layers remains constant throughout the process of formation, while the thickness of the lower layers decreases as the weight of the superimposed strata increases. The same stress conditions develop if we deposit the sand in a vessel with perfectly frictionless side walls such as that shown in Fig. 1*a*, provided that the side walls neither move nor deflect during the process of filling the vessel. The state of stress in the contents of this vessel will be called the *natural state of stress* because it is identical with the state of stress in a natural sand deposit before engineering operations of any kind have been started. Numerous experimental investigations concerning this natural state of stress have led to the following conclusions. This state differs from the two extreme Rankine states of stress inasmuch as the hydrostatic pressure has a value, K_o , intermediate between the two extreme Rankine values K_r and K'_r . The value K_o is called the natural hydrostatic pressure ratio. Since K_o is also a constant, the pressure on any plane section through the sand increases in simple proportion to the depth below the surface. The following values of K_o were obtained and verified by several independent experimental methods:

Dense sand	$K_o = 0.40$ to 0.45
Loose sand	$K_o = 0.45$ to 0.50

The validity of these figures is limited by the condition that the bed of sand to which they refer has never been subject to a temporary surcharge. The application and subsequent removal of a surcharge

seems to increase the value of K_o and to eliminate the hydrostatic pressure distribution.

In order to change the natural state of stress shown in Fig. 1 under the letter *A* into the Rankine state of minimum lateral pressure shown under the letter *B*, the sand must be given an opportunity to expand laterally. This could be done by permitting one of the side walls of the vessel to yield parallel to its original position, as shown in Fig. 1*d*. However, the reduction of K_o to K_r produced by such a movement would be strictly limited to the immediate vicinity of the yielding side wall because at a greater distance from the wall the friction between the bottom of the vessel and the base of the fill prevents the expansion from spreading over the entire contents of the vessel. Hence, in order to produce the proposed modification of the state of stress, the friction between the bottom of the fill and the bottom of the vessel must be entirely eliminated. In practice no such elimination can be effectuated. Hence the process can only be performed in our imagination. On the other hand, the total amount of lateral expansion required to reduce the hydrostatic pressure ratio from K_o to K_r throughout the mass of sand can be reliably determined from what we know concerning the relation between stress and strain in sands. This expansion is equal to an empirical value, c_r , times the total width, l , of the deposit. The value c_r depends largely on the density of the sand. For a well-compacted sand the value of c_r is approximately 0.015, and for a loose sand it is considerably greater. The lateral expansion shown in Fig. 1*d* is always associated with a subsidence in a vertical direction.

On the other hand, the transition from the natural state of stress to the Rankine state of maximum lateral pressure requires a lateral compression of the sand through a distance $c'_r l$ such as shown in Fig. 1*g*. The value of c'_r seems to be almost identical with the value c_r . The lateral compression is associated with an expansion in a vertical direction.

As indicated in the above discussion, natural sand deposits exist exclusively in the natural state of stress. In order to change this state of stress into a Rankine state of stress for minimum lateral pressure over a width of not more than 100 feet of a bed of sand, the material must be given an opportunity for perfectly uniform lateral expansion through a distance of not less than 1.5 feet. Nowhere in nature is there a possibility for such an important expansion. Hence the states of stress shown in Fig. 1, *B* and *C*, exist exclusively in our imagination and in Rankine's earth pressure theory.

Eighty years ago, when Rankine's theory was published, nothing was known about the natural state of stress of sands and nothing was

known regarding the importance of the lateral expansion required to produce the Rankine state of stress. Therefore the theory appeared to be acceptable. However, at the present state of our knowledge of the relations between strain and stress in sands, the theory can no longer be accepted.

COULOMB'S THEORY

In contrast to Rankine, Coulomb never attempted to investigate the state of stress within the backfill of the lateral support, but merely tried to interpret mathematically the phenomena observed when a lateral

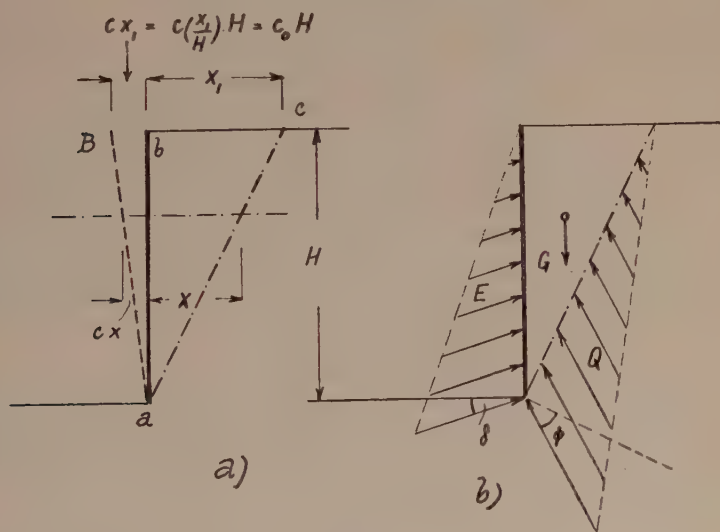


FIG. 2

Distribution of stresses along the boundaries of the sliding wedge according to Coulomb's theory. The abscissæ of aB represent the minimum lateral expansion of the fill required to establish the Coulomb condition.

support fails. The failure of the lateral support of a bank of sand always causes a slip along an inclined surface, ac in Fig. 2*a*, which passes through the lower edge of the back of the support. Coulomb's theory of this phenomenon can be divided into two parts which are based on two different assumptions. The first part, dealing with the total value of the lateral pressure, involves the assumptions that the surface of rupture, ac in Fig. 2*a*, is plane and that the shearing resistance along this

plane is fully mobilized. The total lateral pressure, E , computed on the basis of these assumptions, will briefly be called the *Coulomb pressure*. It represents the smallest value the lateral pressure on the back of a retaining wall can possibly assume. In the computation of this pressure no assumption whatsoever is made regarding the state of stress within the wedge abc (Fig. 2a). As a consequence no information is obtained regarding the position of the force E with respect to the wall.

The second part of Coulomb's theory deals with the distribution of the lateral pressure over the back of the lateral support. In this connection Coulomb simply *assumes* that the lateral pressure increases like a hydrostatic pressure in simple proportion to depth. He does not even attempt to justify this assumption.

No serious objection can be raised against the first part of Coulomb's theory as applied to sands, because for practical purposes both assumptions involved in this part are justified. Experience has shown that the curvature of the plane of rupture is very small, and the lateral yield of retaining walls and of the strutting of cuts in sands is almost always sufficient to mobilize at least the major part of the shearing resistance along the boundary ac (Fig. 2a) of the wedge. In doubtful cases the validity of this second assumption should be examined. An example of such an analysis has been published by the author ("Engineering News-Record," May 17, 1934).

In order to pass an opinion on the conditions for the validity of the second part of Coulomb's theory concerning the distribution of the lateral pressure over the back of the lateral support, it is necessary to investigate the effect of the lateral yield of the support on the state of stress in the adjoining part of the backfill.

The state of stress in the backfill of a perfectly rigid wall can be assumed to be almost identical with the natural state of stress represented in Fig. 1, A . If the wall is allowed to yield in a horizontal direction, the sand adjoining the back of the wall expands laterally, with the result that the lateral pressure decreases. As soon as this expansion exceeds a certain critical value, depending on the elastic properties and the depth of the backfill, a slip occurs along an inclined surface ac (Fig. 2a). To the left of ac the outward movement of the wall produces a gradual transition from the natural state of stress into a state involving a minimum lateral pressure. To the right of ac (Fig. 2a) the lateral expansion produced by the outward movement of the wall is practically nil, because the lateral confinement of the sand located beneath the base of the fill prevents this part of the fill from participating in the expansion. Hence, in contrast to Rankine's assumptions, the lateral yield of

the wall produces merely a *strictly localized* transition from the natural state into one of complete mobilization of the internal friction.

The lateral expansion required for reducing the hydrostatic pressure ratio to its minimum value throughout the wedge-shaped zone abc , in Fig. 2a, increases from the foot of the bank towards the crest of the wall, as indicated by the distance between the lines ab and aB (Fig. 2a). The expansion of the sand through the distance between the lines ab and aB in Fig. 2a can be produced by a rotation of the lateral support around its lower rim. After the expansion has occurred, the hydrostatic pressure ratio is equal to K_c throughout the entire wedge abc . The value K_c represents the minimum hydrostatic pressure ratio for the backfill of a rough lateral support. It is always smaller than the Rankine value K_r for the same backfill. If the back of the wall is perfectly frictionless, the value K_c becomes identical with K_r . A constant value of K throughout the wedge abc also involves a hydrostatic distribution of the lateral pressure over aB (Fig. 2a). This conclusion is identical with Coulomb's assumption regarding the distribution of the lateral pressure over the back of a retaining wall. Fig. 2b shows the distribution of the lateral pressure E over the back of the wall and of the reaction Q over the plane of rupture according to Coulomb's theory. The corresponding distribution of the lateral pressure over the back of the lateral support will be briefly called the *hydrostatic pressure distribution*.

Fig. 3a represents the ideal relation between the average yield of a wall, the location of the center of pressure and the hydrostatic pressure ratio K for a wall which yields by tilting around its lower edge. The back of the wall is supposed to be perfectly frictionless because the friction between the sand and the wall is likely to have at least some disturbing influence. The abscissæ of the diagrams represent the average distance of yield in fractions of the depth H of the fill. In the lower diagram the ordinates determine the vertical distance between the center of the pressure and the foot of the wall in fractions of the depth H of the fill. Since the tilting movement produces simultaneous mobilization of the internal friction in the sand adjoining the wall, the distribution of the pressure remains practically hydrostatic throughout the process, involving a location of the center of pressure at an elevation equal to one third of the depth of the fill. The ordinates of the curve C'_k in the upper diagram are equal to the hydrostatic pressure ratio K . The shape of the curve C'_k was estimated from the results of experimental investigations concerning the relation between stress and strain for sands. Its curvature is due to the fact that the strain in sands increases at a higher rate than the corresponding stresses.

THE NON-HYDROSTATIC PRESSURE DISTRIBUTION AND THE ARCHING EFFECT

The validity of the ideal diagram shown in Fig. 3a is limited to the ideal case in which the hydrostatic pressure ratio decreases in every

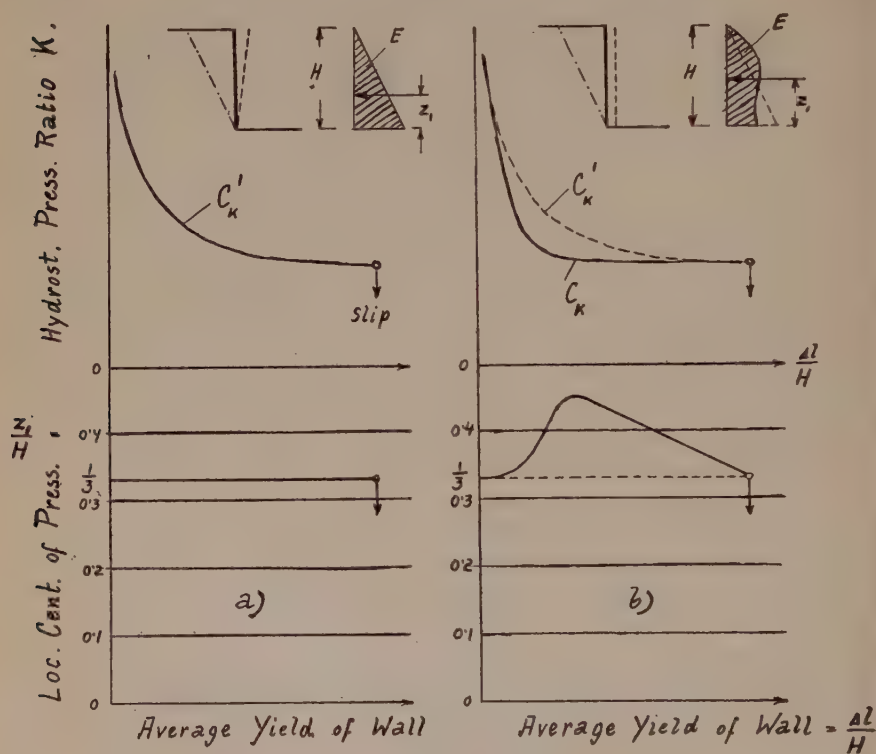


FIG. 3

Ideal relations between average yield of lateral support (abscissæ), hydrostatic pressure ratio K (ordinates upper diagram) and location of center of pressure (ordinates lower diagram) for a frictionless lateral support which yields by tilting (left hand diagram) or by advancing parallel to its original position (right hand diagram). Shaded areas represent the distribution of lateral pressure immediately after the total lateral pressure has become equal to Coulomb value.

point of the wedge at the same rate. To satisfy this condition the lateral support must yield by tilting around its lower rim. On the other hand, if a lateral support yields in any other fashion, involving an out-

ward movement over the entire height, for instance as shown by the line $a_1 b_1$ in Fig. 4, the following events will occur. Owing to the relatively excessive lateral yield of the lower part, ade , of the wedge abc in Fig. 4, the hydrostatic pressure ratio for this lower part assumes its minimum value, K_c , at an early stage of the outward movement of the wall. At this same stage the upper part, $bcde$, of the wedge is still in an initial state of lateral expansion, involving a value $K > K_c$. The ener-

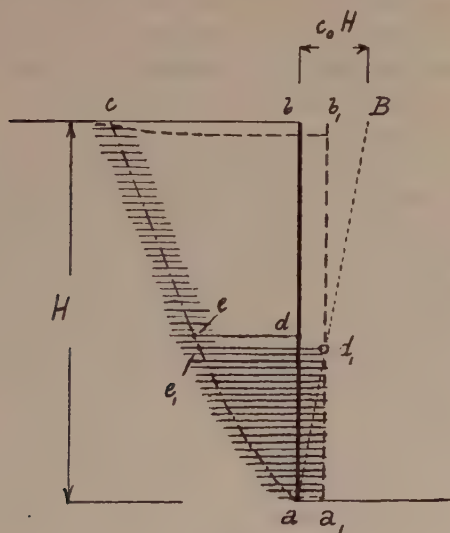


FIG. 4

Mechanical causes of non-hydrostatic pressure distribution over the back of lateral support after the support has yielded from ab to a_1b_1 . abB = minimum yield required to produce hydrostatic pressure distribution, aa_1bb_1 = actual yield. Owing to the excessive lateral yield of the lower part, ad , of the lateral support, the lower, shaded part of the wedge abc subsides. The upper part must follow in spite of inadequate lateral expansion which, in turn, mobilizes the maximum shearing resistance along the balance ec of the surface of rupture.

getic horizontal expansion of the lower part of the wedge involves a subsidence of its upper boundary de into the position d_1e_1 , which in turn causes the upper part, $bcde$, of the wedge to descend. This downward movement mobilizes the frictional resistance of the sand along the surface ce (Fig. 4). Along the section ae this resistance was already mobilized at an earlier stage. Once the frictional resistance along ac is fully

mobilized, the total lateral pressure automatically assumes the theoretical Coulomb value, regardless of what the state of stress within the wedge abc may be. Since the upper part of the wedge is still in a state of incomplete lateral expansion, the friction along ce transfers part of the weight of this upper part on to the fill located at the left of ce , and this in turn reduces the vertical pressure on d_1e_1 . The reduction of the vertical pressure on d_1e_1 (Fig. 4), due to friction along the lateral boundary, e_1c , of the superimposed strata $b_1cd_1e_1$ in a state of lateral restraint, is called the *arching effect*. Owing to the arching effect the lateral pressure exerted by the lower part of the backfill decreases. The total lateral pressure E remains unchanged. Therefore the lateral pressure of the upper part of the backfill is bound to increase, which in turn causes the center of the pressure to rise.

Any further yield of the lateral support beyond the position required to reduce the total lateral pressure to the theoretical Coulomb value E merely changes the distribution of the lateral pressure over the back of the lateral support while the total pressure remains constant. During this process the difference between the real and the hydrostatic pressure distribution gradually diminishes. Finally the hydrostatic pressure ratio K becomes equal to K_c throughout the wedge, whereupon a slip occurs. At the same time, the distribution of the lateral pressure becomes hydrostatic.

The non-hydrostatic pressure distribution involves a location of the center of pressure above the lower third. Since the last stage of the process prior to the slip is associated with an approach to the hydrostatic conditions, the relation between the average yield of the wall, the location of the center of pressure, and the average hydrostatic pressure ratio K should be as shown in Fig. 3*b*. The diagrams in the upper right corner of the figure show the position of the wall and the corresponding pressure distribution at the instant when the total lateral pressure assumes the Coulomb value. Any further outward movement of the wall causes a gradual transition of the distribution of the lateral pressure shown in Fig. 3*b* into that shown in Fig. 3*a*, while the total lateral pressure E represented by the shaded area remains unchanged.

It should be noticed that the curve C_k in Fig. 3*b* is shown to approach the horizontal tangent far more rapidly than does the curve C'_k in Fig. 3*a*. This assumption was suggested by the following reasoning. In the case represented by Fig. 3*a*, the wedge expands in a uniform fashion, because the wall is supposed to yield by tilting around the lower edge of its back. As a consequence the lateral pressure does not assume the Coulomb value until the hydrostatic pressure ratio becomes

equal to the minimum value K_c throughout the wedge. On the other hand, if the wall yields parallel to its original position, as in the case represented by Fig. 3*b*, a very small horizontal displacement is sufficient to produce a general subsidence of the sand located between the lateral boundaries of the wedge. This subsidence mobilizes the frictional resistance within narrow zones as it is shown in Fig. 4, though the expansion of the upper part of the wedge is still incomplete. This phenomenon can be compared with the state of stress in a funnel-shaped bin. As soon as the bottom of such a bin is allowed to yield, the shearing stresses along the walls of the bin assume their maximum value, although there is no lateral expansion of the contents of the bin.

EMPIRICAL DATA REGARDING THE NON-HYDROSTATIC PRESSURE DISTRIBUTION

According to Coulomb's theory the pressure of the sand on the back of any lateral support, the timbering of cuts included, should increase like a hydrostatic pressure in direct proportion to the depth. In contrast to this widespread conception many contractors maintain, on the strength of their personal experience, that this is never the case in connection with the vertical sides of a cut. This fact alone should suffice to produce a sceptical attitude towards the hydrostatic pressure theory.

Fig. 5*a* shows the results of direct measurements made by M. Miller on Flatbush Avenue, New York, in 1916, quoted by H. G. Moulton (reference given above). The lateral pressure was computed "from the deflection of rangers over a bank area measuring 22 feet in a horizontal direction and 55 feet in a vertical direction." Below a depth of 60 feet the cut was occupied by the completed structure. The width of the cut was 85 feet and the soil consisted of coarse sand mixed with 20 to 30 per cent of clay and some gravel. The dotted line *ab* in Fig. 5*a* shows what the distribution of the lateral pressure should be according to the hydrostatic theory. The difference between the hydrostatic and the observed pressure distribution is by far too important to be ignored as an item of no practical consequence.

Experimental data concerning the relation between the lateral yield of the wall, the location of the center of pressure, and the hydrostatic pressure ratio were obtained by the writer in connection with large-scale earth pressure tests at Massachusetts Institute of Technology in 1929. These tests were described in several articles in "Engineering News-Record," 1934. Fig. 5*d* shows the results of two series of perti-

nent tests, both of which were performed on a sand with an effective size of 0.54 mm. in a compacted state. In series I the wall yielded by tilting around a horizontal axis located at a depth of 1.67 feet below the base of the fill, as shown in Fig. 5b. In series II, the wall was moved out parallel to its original position, as shown in Fig. 5c. In the lower dia-

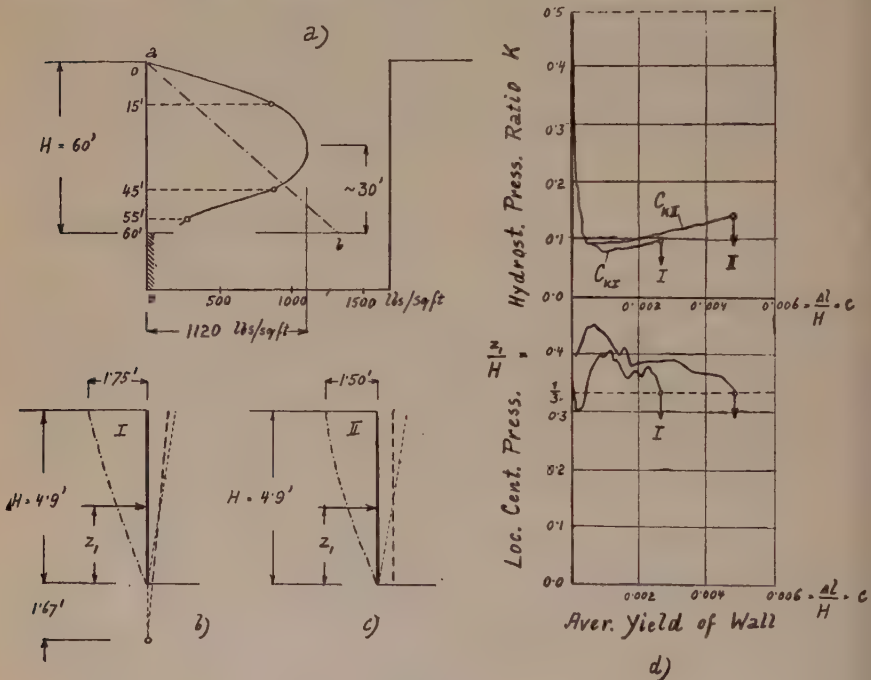


FIG. 5

Empirical evidence for non-hydrostatic pressure distribution. (a) Distribution of lateral pressure over timbering in Flatbush Avenue, New York. (b) and (c) Movement of model retaining wall in two different tests, I and II. (d) Relation between average yield of the wall (abscissæ), hydrostatic pressure ratio (ordinates upper diagram) and location of center of pressure (ordinates lower diagram) for tests I and II. The arrows I and II indicate slip in tests I and II.

gram of Fig. 5d the ordinates represent the location of the center of pressure, in the upper diagram the hydrostatic pressure ratio, and in both diagrams the abscissæ indicate the average yield of the wall. By comparing the theoretical diagram (Fig. 3b) with the empirical diagram (Fig. 5d) we recognize, first of all, that these two diagrams are practi-

cally identical as far as the essentials are concerned. This identity can be considered an experimental confirmation of the reasoning on which the theoretical diagram Fig. 3*b* was based. In addition, an analysis of the data shown in Fig. 5*d* leads to the following conclusions. The maximum arching effect disclosed by the highest position of the center of pressure develops at the instant when the total lateral pressure, expressed by the ratio K in Fig. 5*d*, assumes its smallest value. The smallest value of the total pressure of the sand on the lateral support is identical with the Coulomb value. Therefore the facts shown in Fig. 5*d* demonstrate that the Coulomb value is by no means necessarily associated with a hydrostatic distribution of the lateral pressure. A yield of the wall beyond the distance required to produce the maximum arching effect causes a slight but steady increase of the total lateral pressure. This fact suggests that the slip, which is indicated in Fig. 5*d* by arrows, is preceded by a decrease of the shearing resistance along the inclined boundary of the wedge. The highest position of the center of pressure depends on the type of the movement of the wall. The more this movement approaches simple tilting around the foot of the back of the wall, the closer the center of pressure remains to the lower third of the depth of the fill. At the same time, the average yield corresponding to the highest position of the center of pressure increases. The type of movement also has a marked influence on the curvature of the surface of rupture. In series II, involving a movement of the wall parallel to its original position, the width of the top of the wedge was 15 per cent smaller than it was in series I, though the minimum value of the total lateral pressure was in both series almost exactly the same. Finally it should be mentioned that the abscissæ of the arrows I and II in Fig. 5*d* correspond to almost equal yields of the upper rim of the wall in the two series of tests. In both cases the yield of the upper rim was approximately equal to 1.5 per cent of the top width of the wedge, though the average yield of the wall was different. Hence it seems that the slip which is indicated by the arrows does not occur until every part of the wedge, including its uppermost part, has expanded through a certain minimum distance regardless of the average yield of the wall. This minimum distance is c_0H in Fig. 4. In both tests this distance was approximately equal to $0.005 H$. On the other hand, the hydrostatic pressure ratio K for the total lateral pressure seems to depend on the average yield only. In this connection attention should be called to the striking similarity between the curves C_{kI} and C_{kII} in Fig. 5*d*. Both curves closely resemble the curve C_k in Fig. 3*b*, but neither of them has any similarity to the curve C'_k in Fig. 3*a* corresponding to the

imaginary case of a perfectly frictionless lateral support which yields by tilting around its lower edge. The rough model retaining wall to which case I in Fig. 5 refers also yielded by tilting, although the axis of rotation was located at some depth below the foot of the wall. Hence the striking difference between the curve C'_k in Fig. 3*b* and the curve C_{kI} in Fig. 5*d* suggests that the friction along the back of the model retaining wall (Fig. 5*b*) was sufficient to invalidate the reasoning on which Fig. 3*a* was based.

LIMITATIONS TO THE VALIDITY OF COULOMB'S EARTH PRESSURE THEORY OF THE LATERAL PRESSURE OF SAND

Owing to the facts presented in the preceding paragraph, the validity of Coulomb's theory is limited to the case in which the lateral yield of the support exceeds certain minimum values. The yield required to reduce the total lateral pressure of the sand to the Coulomb value is very much smaller than the yield required to establish a hydrostatic distribution of the lateral pressure. Hence in the process of transition from the state of complete lateral confinement into the state described by Coulomb's theory, two well-defined stages can be distinguished. These two stages are illustrated by Fig. 6. During the first stage, involving an advance of the lateral support from its initial position ab into the position a_1b_1 , the lateral pressure rapidly decreases from the initial value $K_o \cdot \frac{1}{2} H^2 s$ to the Coulomb value $K_c \cdot \frac{1}{2} H^2 s$. This transition requires an average yield of the wall through a certain distance which depends on the nature and the density of the sand and on the height of the support. For a dense sand this distance was found to be equal to $0.0005 H$. In Fig. 6 this distance is represented by the abscissa of point A . Since point A is located at one half of the height of the wall, its abscissa represents the average yield regardless of the position of the lower rim, a , of the lateral support. However, at this stage the distribution of the lateral pressure over the lateral support has no similarity whatsoever with a hydrostatic pressure distribution. The importance of the difference between the real and the hydrostatic pressure distribution for the position a_1b_1 (Fig. 6) of the lateral support increases with the value of the ratio c_u/c_m . A difference in the distribution of the lateral pressure also involves a different elevation of the center of pressure above the foot of the support.

The second stage, consisting of an advance of the wall from the position a_1b_1 into the position a_2B in Fig. 6, involves a gradual transition from the non-hydrostatic into the hydrostatic distribution of the lateral

pressure at a practically constant or slightly increasing value of the total lateral pressure. As soon as the upper rim of the wall reaches point B , the distribution of the lateral pressure becomes almost hydrostatic, and at the same time a visible and audible slip along an inclined surface of rupture, ac in Fig. 6, occurs.

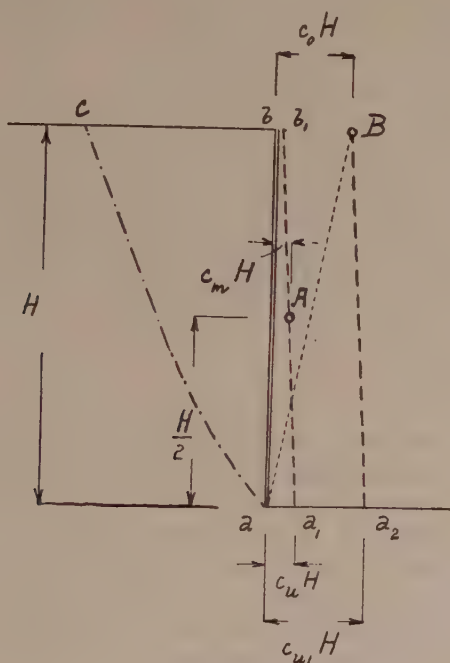


FIG. 6

Conditions for validity of Coulomb's theory. While the wall moves from ab into any position passing through point A , the total lateral pressure decreases from natural to Coulomb value. Yet at this stage the distribution of lateral pressure is non-hydrostatic. During further movement into any position passing through B , the distribution of lateral pressure gradually becomes hydrostatic while the total pressure remains practically unaltered. This second stage terminates with a slip.

Any further yield of the wall merely causes a slight increase of the lateral pressure due to progressive disintegration of the structure of the sand at an unaltered or slightly increased total lateral pressure. During all the transitions connected with an advance of the wall from the position ab (Fig. 6) to a position beyond a_2B the change of the state of

stress in the sand is practically limited to the zone *abc*. To the left of the boundary *ac* of this zone the state of stress remains practically unchanged during the entire advance of the wall.

For any sand in a loose state the distribution of the lateral pressure seems to be almost hydrostatic from the very beginning of the first stage throughout the following ones. At the same time, the average yield $c_m H$ required to obtain the theoretical Coulomb pressure seems to be very much greater than $0.0005 H$.

Any failure of a retaining wall by tilting or sliding involves the passage of the upper rim of the back of the wall through the position *B* in Fig. 6. This event is automatically associated with a transition from the non-hydrostatic into the hydrostatic distribution of the lateral pressure. Therefore the facts shown in Fig. 6 require no modification of the present method of the computation of the lateral pressure on retaining walls, provided that the backfill consists of dry sand, and that the upper rim of the retaining wall can yield at least through the distance $bB = c_o H$ shown in Fig. 6.

On the other hand, in connection with the lateral pressure of sand on a lateral support with a very limited capacity for yielding, such as the strutting of cuts, the non-hydrostatic pressure distribution associated with a position of the upper rim of the lateral support on the left side of point *B* in Fig. 6 becomes a factor of decisive practical importance. The assumption of a hydrostatic pressure distribution over supports of this type involves an error which may even be fatal.

Hence the fundamental misconception associated with the traditional earth pressure computations does not reside in the theories as such. It lies in the failure of the designers to consider the limitations on the validity of the theoretical results. Fig. 6 reveals these limitations at a single glance.

Owing to the important effect of apparently insignificant displacements of the lateral support on both the distribution and the intensity of the lateral pressure, no experimental data can be obtained concerning this important subject except by using extremely rigid model retaining walls capable of any type of lateral movement. Up to this time the only device which satisfies this fundamental requirement is at Massachusetts Institute of Technology in Cambridge, Massachusetts.

LATERAL PRESSURE OF COHESIVE SOILS.

The same type of reasoning which led to Fig. 6 applies without modification to cohesive soils. From general construction experience the following tentative conclusions were derived concerning the earth pressure exerted by cohesive soils. For sandy, cohesive soils the difference between the real and the hydrostatic pressure distribution may be still more important than it is for sands. In many cases the greatest lateral pressure develops in the vicinity of the upper rim of the cut. This fact is known to every experienced foreman. For plastic clays the value $c_m H$ in Fig. 6 is likely to be far in excess of the greatest possible shortening of the struts under axial pressure. If such is the case the earth pressure theories fail to furnish any information on the lateral pressure which acts on the timbering. Further complications are likely to arise on account of volume changes produced by continuous rains. For this reason the cohesive soils were excluded from the preceding analysis.

CONCLUSIONS

(1) The fundamental assumptions of Rankine's earth pressure theory are incompatible with the known relation between stress and strain in soils, including sand. Therefore the use of this theory should be discontinued.

(2) The results obtained from the other classical theories can only be accepted for practical purposes if certain conditions concerning the lateral expansion of the supported sand are satisfied. These conditions are graphically shown in Fig. 6 of this paper.

(3) The total lateral pressure of the sand does not assume the theoretical value unless the average yield of the lateral support exceeds a certain minimum value, $c_m H$, wherein H is the depth of the fill and c_m is a coefficient whose value depends on the nature and the density of the sand. For a dense sand the value c_m is of the order of magnitude of 0.0005, and for a loose sand it is considerably greater. Under normal conditions this requirement is satisfied by both the retaining walls and the timbering in cuts.

(4) The distribution of the pressure of sand on the back of a lateral support does not agree with theory unless the yield of the support exceeds in every point the value determined by the abscissæ of $aB = c_o H$ in Fig. 6. For a dense sand this value c_o is of the order of magnitude of 0.005. In the upper part of timbered cuts this condition is very seldom satisfied. Therefore no agreement can be expected between the

real and the theoretical distribution of the pressure over the lateral support of the banks in cuts.

(5) For identical soil conditions and equal yield of the lateral support, the total lateral pressure on the support is the same. Yet the distribution of the pressure over this support varies enormously according to the distribution of the yield over the face of the bank. The more this distribution departs from a straight line through the foot of the bank, the more important the departure from the hydrostatic pressure distribution is likely to be. No pertinent information of practical value can be obtained except by direct measurements under field conditions similar to those which were made by M. Miller on Flatbush Avenue, in New York. However, the measurements should always be made not on the rangers but on the struts.

THE GRAND COULEE DAM — THE WORLD'S GREATEST CONVEYORIZED CON- STRUCTION PROJECT

(Papers presented at a meeting of the Boston Society of Civil Engineers on December 18, 1935)

EXCAVATION AND CONVEYOR SYSTEM

BY STANLEY M. MERCIER*

FROM a "methods" viewpoint, the construction of the Grand Coulee Dam is notable in two major respects: first, in the eminent success of a large-scale conveyor system, boldly applied to the handling and stacking of excavation; second, in the unusual layout and flow features of the aggregate plant, which is by far the largest ever built. The contractor is the Mason-Walsh-Atkinson-Kier Company.

Grand Coulee is located on the Columbia River in the State of Washington, about 100 miles west of Spokane. The purpose of the impoundment is that of irrigating some 1,200,000 acres of land which would be excellent for farming did it not lack for water. A by-product will be the generation of hydro-power for the irrigation system and later for other purposes, perhaps. As now contemplated, the final dam will rise to a height of about 550 feet, and have a length of 4,300 feet along its crest and a width of 500 feet at its base. With an annual run-off of 79,000,000 acre feet, it is capable of producing some $2\frac{1}{2}$ million horsepower. Estimates have it that the project cannot be completed in its entirety much before the close of the current century.

When completed to its ultimate size, the dam will contain about 11,500,000 cubic yards of concrete. Foundations for this huge structure have required the removal of, roughly, 17,000,000 cubic yards of overburden, consisting mainly of gravel, sand and clay, together with some boulders, to a depth which varies from 50 to nearly 300 feet. Of this total overburden, approximately 12,000,000 yards will have been transported by a 60-inch belt conveyor system a distance of over a mile in a net lift of over 500 feet maximum, at the rate of 4,000 tons per hour working 21 hours a day.

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CAPACITY OF CONVEYOR SYSTEM

That the conveyor system has been successful is proved by the action of the contractor in the building of a conveyor bridge across the river to the east side excavation, using the conveyor line that served for transportation from the west side excavation. On the west side job the conveyors met gratifyingly the "million-a-month" schedule of full-time operation set for it, handling 7,000,000 yards in seven months. This production was achieved at a steady rate, as shown by performance in the three



FIG. 1

The tributary conveyors converge to a central point and empty into a hub or surge feeder that in turn delivers to the main line. The feeder into which these wagons are emptying is buried beneath the dumping level.

final months: in May, 1,096,470 yards; in June, 1,097,946 yards; in July, 1,083,457 yards. The record day's production during this period was 50,839 yards. During the three 7-hour shifts of each day the conveyors operated almost continuously, delays due to the conveyors themselves accounting for no more than 5 per cent of scheduled running time.

As now planned, the dam is to be built in two stages. The first stage, which is covered by the present contract, provides for construction of the foundations for and a portion of the dam itself.

Test borings in the area of the west side excavation indicated that the upper levels of the digging would consist mainly of sandy deposits with a surface layer of boulders. Tests of the middle bed disclosed a densely compacted lava dust of clay-like characteristics. To assure a solid footing for the concrete, it was necessary to remove some 10 feet of rock from the bottom of the excavation. The material, in general, weighed about 110 pounds per cubic foot loose. Overburden removed from the excavations is being conveyed to Rattle Snake Canyon, roughly one mile from the west side excavation. This canyon is about 250 feet deep, nearly a mile wide, and several miles long.

Fig. 1 shows the arrangement of the conveyors within the west side excavation area and in the main line to the dumping grounds. The west



FIG. 2

Here is shown the grizzly covering a feeder for the purpose of excluding boulders too large for the conveyors to handle. The large rocks are nosed off by bulldozers.

side job is now completed, and this same system is being used in the east side excavation, connected by a trestle bridge across the river on which is a conveyor that connects with the west side main line leading to the canyon.

EXCAVATION

Overburden is dug by power shovels of 2 to 5 cubic yard capacity, and loaded into 12 to 24 cubic yard side-dump crawler wagons drawn by Diesel tractors and into standard pneumatic tired trucks. These wagons and trucks take the material to the tributary conveyors, which converge to the 6-inch main line conveyor like the spokes of a wagon wheel. At the extremity of each tributary conveyor is an apron feeder

into which the vehicles dump, and at the hub is a surge apron feeder which regulates the flow from the tributary conveyors to the main line belts. Finally, at the end of the main line is a mobile extensible stacker which spreads material over the dump bank.

Cuts are taken in benches or steps of about 20 feet. The excavating is in progress at several different elevations, but each power shovel generally works on the same level as the dump feeder it serves. In consequence, the wagons and trucks travel from shovels to dump feeders on graded roads which generally are level, but may be descending, and



FIG. 3

This stacker is the key to the success of the Coulee conveyor system. Extremely flexible, extensible and self-propelled, it disposes of the muck as fast as the conveyors deliver it, and does this continuously.

more rarely, ascending. Each dump feeder is designed to serve a more or less fixed area of excavation, upon completion of which it is relocated at a lower level. Furthermore, owing to the great depth of the excavations, relocation of the hub feeder position likewise has been required. This last operation was so arranged as not to interfere with continuance of production, by the simple expedient of using an extra feeder as the nucleus of the new set-up, and by transferring tributaries from one system to the other as their tasks are completed.

TRIBUTARY FEEDERS

Tributary feeders are located in pits below the level at which wagons and trucks dump. Over each feeder is a grizzly of heavy beams for excluding oversize boulders. These rocks are nosed off the grizzly by a bulldozer. Above each feeder is a receiving hopper with graduated cut-off gates, to regulate the withdrawal of material in correct amount from each of three compartments. The graduation reduces shearing stresses and permits the delivery of maximum output with a minimum of power. All tributary feeders are self-contained and identical in design, being on 46-foot centers, and having a frame fabricated of heavy I-beams. Each weighs approximately 65 tons. They are driven at a speed of 40 feet per minute by 60-horsepower motors through a herringbone speed reducer. The slow speed shaft on the reducer is extended out on both sides and connected through couplings, to permit use of a double chain drive to the head shaft. The hub feeders are of the same design, except that they are on 29-foot centers and driven at twice the speed.

CONVEYORS

The 60-inch belt conveyors are equipped with 200-horsepower slip-ring motors, which drive through open cut steel gearing and V-belt drives at a speed of 620 feet per minute. The belting is for the most part 32-ounce, 8-ply, with a 3,500 to 4,000 pound tensile strength and a friction value of 20 to 24 pounds. It runs on standard and heavy duty roller bearing idlers, troughing and return idlers being on 3½-foot and 7-foot centers, respectively. The heavy duty idlers are used chiefly within discharge impact zones, as at loading or transfer points, and certain of these are rubber covered.

WASTE STACKER

The waste stacker on the dump consists essentially of three conveying units: (1) an extensible conveyor that is added to in 50-foot long sections as the dump progresses, and whose head end is supported on a 50-foot long, four-wheel truck straddling the second unit; (2) a telescopic unit with a foot end located under the head or discharge of the first unit and arranged to travel freely through 50 feet, receiving its load from the first unit at any point in its range; (3) a 175-foot conveyor boom which is supported at its pivot point and receives the discharge of the second unit from any angle in a swing through 180

degrees, which swing is made under the power of crawler treads on which the boom is supported at an intermediate point.

The crawler support is located sufficiently far back from the boom tip to guard against slips in the dump without introducing undesirable heavy soil pressure under the treads. Its mounting also has full provision for movements to conform to irregular dump surfaces, thus avoiding any twisting or binding stresses caused by irregular surface or failure of the treads to track in a true circle.

To pivot the stacker boom or propel forward the stacker boom and telescopic conveyor, it is not necessary to stop production, at least



FIG. 4

The west side cofferdam cells were filled with material from the excavation by an 870-foot shuttle conveyor, on each end of which was a 200-foot boom conveyor.

not until a forward movement of 50 feet has been accomplished. Even then the stoppage for the purpose of inserting a 50-foot section in the extensible conveyor does not exceed half an hour, and is always so scheduled as to take place during one of the three hourly rest periods between the three shifts daily.

AUXILIARY FEEDER AND BLEEDER CONVEYOR TO COFFERDAM

The excavating conveyor system, assisted by a bleeder conveyor and a shuttle conveyor, was also used to fill the cellular piles of the west cofferdam. At the hub point of the conveyor system was located an auxiliary apron feeder arranged to receive selected material by chutes from one or another of the tributary belts, hence from any part of the

excavation. This auxiliary feeder discharged to the bleeder conveyor, which, in turn, emptied on to an 870-foot shuttle conveyor paralleling the cofferdam piles. At the ends of the shuttle were 200-foot boom conveyors that discharged into the cells. The shuttle conveyor was mounted on a trestle which moved on a 12-foot gauge track. With this arrangement of conveyors, assisted by truck haulage to end sections



FIG. 5

The last stage of the excavation operation, digging the east side pit. For this, the west side main line set-up was retained, the feeders and tributaries were transferred to the east side and a conveyor bridge erected to make the extension.

beyond the 2,000-foot reach of the shuttle conveyor, the cofferdam was completely filled in less than a month at the rate of 10,000 cubic yards per day, some 270,000 cubic yards in all.

All of the conveying equipment, including the stacker and feeders, was furnished by The Jeffrey Manufacturing Company of Columbus, Ohio.

GRAND COULEE AGGREGATE PLANT

BY GORDON F. DODGE *

REQUIRED CAPACITY OF AGGREGATE PLANT

THE aggregate plant now in operation at Grand Coulee is the world's largest. Designed for an output of 1,000 tons per hour of washed and graded product, the plant takes a raw feed of 2,500 tons per hour maximum. Its feed is probably more than double that of any existing plant. The plant will operate three 7-hour shifts daily.

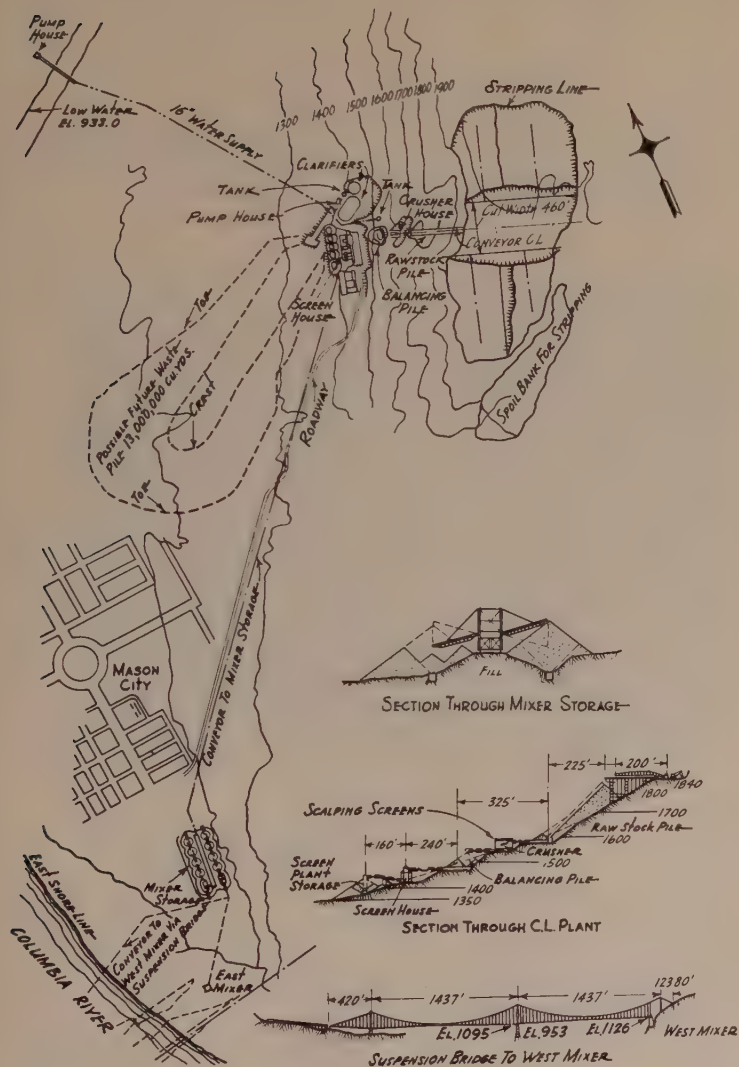
Under the present contract, which calls for the building of the foundations for and also a portion of the dam, about 4,500,000 cubic yards of mass concrete will be poured. The completion of this on scheduled time required the high rate of aggregate production set for the plant. It is contemplated that the Coulee gravel plant will continue to be used in a succeeding contract for completing the dam to a maximum height of 550 feet, with a length of 4,300 feet on its crest and a width of 500 feet at its base. In this work the plant will produce the aggregate for 11,500,000 cubic yards of concrete, which is several times the pouring on any previous job.

SOURCE OF AGGREGATES

Finding a suitable source of aggregates for so great a mass of concrete was no small task. Here, nature with long foresight came to the rescue, and through the agency of glaciers ground up and laid down a large bed of sand and gravel about a mile and a half from the east abutment of the dam. But with all her beneficent foresight, nature kept her mills working too long and hard and thus made an excessive amount of sand, some of it exceedingly fine. But in the main, while the deposit is not ideal in its composition, it is of sufficient quantity and contains materials of suitable quality for processing. The difference between the raw input to finished output represents the maximum rate at which excess sand is rejected. The great volume of concrete will necessitate the preparation of about 15,000,000 cubic yards of finished aggregate and the wasting of some 15,000,000 cubic yards of excess sand.

The location of the plant and the composition of the deposit together require what might be considered radical treatment in comparison with more usual methods. In the first place, the deposit is located more than 900 feet above the river and about 400 feet above any suitable site for a

* Engineer, Construction Machinery Division, The Jeffrey Manufacturing Company, Columbus, Ohio.



ARRANGEMENT OF PLANT

FIG. 6. — AGGREGATE PLANT

preparation plant. In the second place, the deposit carries a disproportionate amount of sand to gravel, the sand running 60 to 70 per cent according to various tests.

METHODS ADOPTED

Sluicing of the waste sand was studied, but this involved discarding all wash water and a considerable cost in labor, to keep the waste within the available area. As water has to be pumped from the river against



FIG. 8

Back view of the aggregate plant, showing conveyor line leading to main storage near the dam site.

a high static head, the cost of pumping equipment, pipe line and power became so high that reclaiming of the water and wasting of dewatered excess sand by conveyors and a stacker indicated a decided economy.

The concreting schedule calls for an unprecedented pouring rate of 12,000 cubic yards per day. Yet the contractors did not feel it necessary to furnish any great reserve storage for aggregate. This deliberate limitation of reserves makes it essential that, at the peak of concreting activity, the gravel plant and attendant belt conveyor systems — over four miles of conveyors are used — perform their respective duties almost continuously during the twenty-one working hours in each day.

As indicated by the general plan in Fig. 1, movement of material is, in general, south, from the pit and through the plant toward the main storage and mixing plants near the dam. The distance from the stockpiles at the aggregate plant to the main storage piles is 4,900 feet. Similarly, belts convey materials from the main storage bins to the east mix plant and, via a suspension bridge across the Columbia River, to the west mix plant through a distance of nearly 4,000 feet.

MINING THE SAND AND GRAVEL

Mining is done with electric shovels and conveyors, but unlike the layout used in excavating, there is no truck haulage from shovels to



FIG. 9

Power shovel discharging into one of two radial conveyors in the gravel pit. The crawler mounting permits the conveyor to follow the shovel wherever it goes in the pit.

conveyors. In place of the mobile carriers, a conveyor system made flexible by two radial conveyors is used. These radial conveyors are each 200 feet long and carried on a steel truss.

RADIAL EXCAVATING CONVEYORS

One of these radial excavating conveyors is seen in Fig. 9. Its tractor-mounted receiving end follows the power shovel wherever it goes in the pit and thus minimizes the dipper swing to about 90 degrees. By this design the radial conveyors, like the extensible stacker in the

wasting process, give life to the conveyors — mobility, extensibility and flexibility. Over the receiving hopper are grizzly bars that reject boulders too large for the conveyors. This grizzly is made purposely flat to minimize "dipper lift" in the dumping operation. It is hinged at one end and fitted with hydraulic cylinders to facilitate dumping of retained boulders. Under the grizzly is a Jeffrey-Traylor electric vibrating feeder having a capacity of 1,250 tons per hour.

With this system, the shovels can be maintained at maximum output, as they work on a semicircular face closely followed by a hopper, so that the swing for each bucket load averages but about 90 degrees. After each 180-degree swing of the radial conveyor, it and the shovel will advance in the direction of the cut a distance regulated by reach of the shovel. Then a reverse swing will be started. After an advance of 170 to 180 feet a new section of that length will be spliced into the main conveyor and the advance continued, making a cut with a bottom width of up to about 500 feet.

For the start, but one radial conveyor is being used, delivering to the main 60-inch conveyor while making a box cut directly across the pit. When this advance measures some 200 feet, one of the north or south 42-inch branch conveyors can be started and the second shovel and radial conveyor put to work, after which full capacity of the plant may be maintained. After the box cut is completed (to a length of about 1,000 feet), both the north and south branch conveyors will be in use delivering at right angles to the main conveyor, and in turn receiving their loads from the radial conveyors.

Mining of the upper 80 to 90 feet of gravel will be done with two 40 to 45 foot depth cuts. After the first cut a second 60-inch main line will be installed at a lower level, and there the same procedure followed as on the upper level.

MAIN CONVEYOR

The main conveyor from the gravel pit (see flow sheet in Fig. 7) delivers on to a high raw stockpile, which provides a generous balancing effect between the pit and the first processing section of the plant. Underneath the raw stockpile is a concrete chamber housing two electric vibrating feeders, each designed to deliver up to 1,250 tons per hour of material to a 60-inch conveyor, which carries its load to two trommel screens. These screens separate the plus 6-inch size gravel and deliver it to a gyratory crusher set to reduce all to minus 6-inch, so that no recirculating loads need be carried. The minus 6-inch material

from the screens joins the crusher product on a 48-inch conveyor, which delivers to a balancing pile of some two or more hours' capacity. Under this balancing pile is another concrete chamber with four electric vibrating feeders, which in pairs deliver to the two 42-inch conveyors leading to the screening plant. By these arrangements flexibility between the crushing plant and the main preparation plant is provided.



FIG. 10

Mile long conveyor line connecting aggregate plant with main storage. One section of this line has a center measurement of 2,157 feet long.

SCREENING PLANT

In the screening plant screen capacity is dictated by the large amount of sand that has to be passed. While the pit will be dry for much of the year, during an appreciable part of the time the moisture content will be high enough to make dry screening impossible without an excess of screen area. For this reason, and also because the terrain favored such construction, the separation plant was built as a wet plant with a vertical flow.

A fortunate condition is that at no place in the deposit is there any indication of clay; so washing is a simple process and no provision has been made for scrubbing. The large amount of sand, however, does

call for an unusual quantity of wash water. The design was based on a possible 20,000 gallons per minute through the plant, with a conceivable loss of 25 per cent in the process.

River pumps are float controlled from a 100,000-gallon surge tank. A check valve in a cross connection to the clarified water line gives that line a make-up source of the same static head as has the clear water. This provision simultaneously prevents entry of clarified water into the fresh water system.

The clarifier pumps are controlled from a 130,000-gallon equalizer tank by floats operating on butterfly valves in the discharge line of each pump, in such manner as to choke the discharge of each pump successively, and shut down at about 20 per cent of capacity of each. Thus the clarifier pumpage will be balanced with the supply from the plant through the clarifiers.

Sludge underflow from the clarifiers, 300 tons per hour maximum, is handled at 50 per cent concentration by special pumps. One of these is a spare, as the service is severe and frequent renewals of runners and liners are anticipated.

Each of the two conveyors from the balancing pile enters the top floor of the plant and delivers to two screens on the floor below. As the aggregate material leaves the incoming conveyor and during screening, reclaimed (clarified) water is generously applied, and a final rinse using make-up water is added through sprays near the discharge ends of the screens.

GRADES OF GRAVEL AND SAND

Specifications stipulate four grades of gravel: (1) cobbles between 6 and 3 inches; (2) coarse between 3 and $1\frac{1}{2}$ inches; (3) medium between $1\frac{1}{2}$ and $\frac{3}{4}$ inches; and (4) fine between $\frac{3}{4}$ and $\frac{3}{16}$ of an inch. Sand is to have a fineness modulus of $2\frac{1}{2}$ to 3 by separation, and blending in proper proportions of these three sizes: 4 to 20 mesh; 20 to 48 mesh; and 48 to 100 mesh.

The two larger sizes of gravel are removed by the four upper screens and delivered through "lowering ladder" chutes to collecting conveyors two floors below. The minus material passes to eight screens on the floor next below, where the same method of applying wash and rinse water is used. Here the two smaller sizes of gravel are separated and delivered through lowering ladders to their respective conveyors on the floor below. From these collecting conveyors, four cross conveyors carry the four sizes of gravel and deliver them through lowering ladders into their respective piles over the plant storage tunnel.

This system of grouping the screens on two floors and the collecting conveyors all on a single floor lower down, and of using lowering ladders, while adding to the necessary chute work, so compacted the plant and saved in conveyors and supports as to effect a material saving in cost.

SAND TREATMENT

The sand, because of its large volume and wide variation in fineness modulus, requires more complicated treatment. From each pair of the eight final screens a launder carries the sand and water to a pair of Jeffrey drag type sand dewaterers, where the water and minus 100-mesh sand is overflowed to the clarifiers and the dewatered sand delivered to two conveyors under the discharge lips. This sand may be divided by chutes in any desired proportion between these two conveyors, one of which goes direct to the waste dump and the other to the sand classifiers.

Such portions of the fractions as may be in excess of what is needed are diverted at the classifier discharges to a conveyor, which carries them to the waste conveyor system. This conveyor system ends in a stacker, which is a narrowed copy of the 60-inch stacker which proved itself the key to success in the high rate disposal of muck from the dam excavation. As does the excavation stacker, the waste sand stacker permits continuous and uniform disposal of material on the dump. As previously noted, it will likely be required to handle upward of 15,000,000 cubic yards of waste sand.

The finished and dewatered fractions, or such portions as are desired of each, are carried by separate conveyors and spread by trippers into three hillside drainage bins with open joint, tile underdrains. After a period of time for drainage the three fractions of sand are moved over a reclaiming tunnel by a traveling dragline derrick. In the reclaiming tunnel is a series of variable speed belt feeders that feed just the desired proportion of each fraction on to a belt conveyor. Thus properly proportioned, the sand is delivered through two Jeffrey continuous sand mixers, which mix the sand and break up any lumps caused by moisture. The discharged sand is thence carried over a conveyor and tripper for bedding in a pile over the plant storage tunnel, ready for transfer to main storage.

CONVEYOR SYSTEM FOR AGGREGATES

From plant storage the aggregates are carried over a five-section conveyor line to a Jeffrey airplane type tripper at the main storage pile. In its entirety this conveyor system has a length of over 6,100 feet.

One section has a length of 2,157 feet, which, it is believed, makes it the longest single conveyor of its capacity (1,200 tons per hour) ever used.

The airplane tripper has imparted compactness to the main storage yard. It also has avoided the need for either a system of trestles or for rescreening aggregate that would be broken by ordinary stockpiling methods. The tripper is a high steel traveling structure carrying a 42-inch main belt and two 42-inch wing belts each 75 feet long and driven by one 40-horsepower gearmotor. To minimize breakage, each



FIG. 11

This Jeffrey airplane tripper carries a 42-inch main belt and two 42-inch wing belts. These last are hinged for raising and lowering, to minimize degradation.

wing belt is hinged and may be independently raised or lowered to positions 17 degrees above or 18 degrees below horizontal. For this purpose two $7\frac{1}{2}$ -horsepower self-locking worm-gear hoists are used. Traversing of the tripper through its 441 feet of movement is by means of a 20-horsepower gearmotor, which drives four of eight wheels through chain and sprocket and pinion and gear reduction, to give a speed of 20 feet per minute. When not in movement the structure is held in place by a magnetic brake on the traverse motor.

All five grades of aggregate are carried separately and in turn by the conveyor system of which the airplane tripper is a part. Delivery

to this conveyor system is effected by air-operated, remote controlled gates. The operator on the airplane tripper over the main storage piles selects the gate to be opened in the plant storage tunnel. This is accomplished by a multiple switch and a 10-pair electric cable to solenoid operated air valves on the gates. The same cable carries telephone lines and a signal line, the latter lighting lamps on the panel to show that the desired gate movement has been completed. A similar gate system and control, operated from the concrete mix plants, govern the flow of aggregate from main storage to mix plant bins.

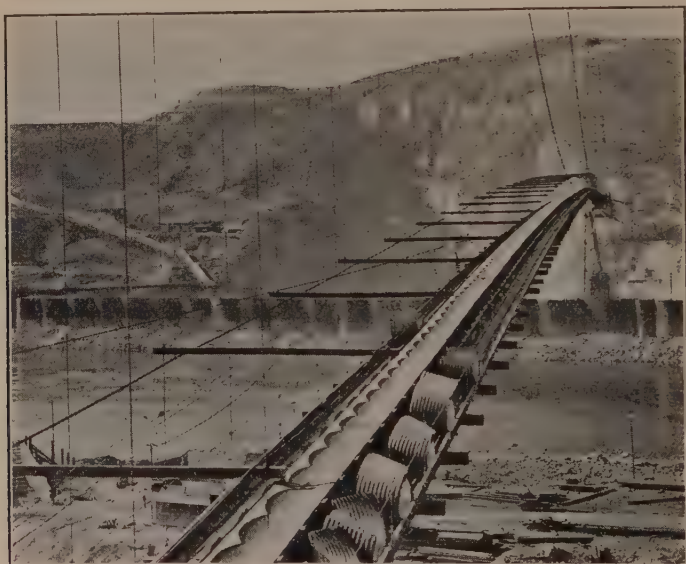


FIG. 12

The conveyor line (before being covered) to the west mix plant, carried on a two-thirds of a mile long suspension bridge.

CONVEYOR LINE TO WEST MIX PLANT

The conveyor line to the west mix plant is of unusual interest in that it crosses the river on a suspension bridge having two 1,437-foot spans and one 420-foot span. The tower between the two main spans is mounted on a cell cluster in the west cofferdam above the top of which it extends 290 feet. This bridge, nearly two-thirds of a mile long, is designed for a loading of 400 pounds per linear foot. In addition to

conveying aggregate, it carries the pipe for bringing cement from the west side of the river to the east mix plant.

All units in the aggregate processing and handling, from the gravel pit to the concrete mix plants, are covered by an elaborate interlocking electrical control system.

CEMENT STORAGE AND BLENDING PLANT

As cement is supplied from several sources, a combined cement storage and blending plant has been installed to insure a uniform concrete throughout the pouring of the dam. Each brand of cement is stored separately in one or another of eight 5,000-barrel steel silos, the transfer from box cars being made by portable cement pumps. The cement is reclaimed from one line of four silos by a 20-inch, 160-foot long, helicoid screw conveyor having a capacity of 600 barrels per hour, and from the remaining four silos by separate cross-screw conveyors of the same type, that discharge into the collecting screw. The collecting screw in turn delivers to a 99-foot centers continuous bucket elevator, which discharges through a bifurcated fly-gated chute to either or both of twin blended cement silos of 5,000 barrel capacity each.

Blended cement is reclaimed from either or both silos through a twin assembly of screws each having a capacity of 500 barrels per hour. These empty through common discharge to the feed opening of a pump, which impels the cement pneumatically to either of the two concrete mix plants through 11-inch, outside diameter, pipe.

CONVEYORS FROM MAIN STORAGE PILE

The conveyor from the main storage pile to the east side mix plant and also that spanning the river to the west mix plant have a rated capacity of 700 tons per hour under continuous loading. But as each is to carry the five different grades of aggregate separately, a blank section will be left on the belt between each two adjacent grades of aggregate. These blanks will be created by intervals between the closing of one gate and opening of the next gate in the tunnels at the main storage piles. However, even with these delays, the belts will handle 600 tons per hour, thanks to the precision of the remote control system coupled with the automatic gates.

MIXING PLANTS

As before indicated, the job is to be equipped with two mix plants, one on each side of the river and each having four 4-cubic yard mixers. These plants are each equipped with automatic weighing batchers under octagonal bins, whose eight compartments consist of two bins for each of the three larger grades of aggregate and one bin for each of the two smaller.

Each class of material, including cement and water, is measured by automatic weighing devices. The four mixers are charged and dumped in sequence, in a 3-minute operating cycle for each. Continuous operation of seven of the eight mixers in the two plants will meet the 12,000-cubic yard peak of the concreting schedule. It is on the basis of this schedule that the 1,000 tons per hour maximum output of finished aggregate was fixed.

All of the conveying equipment, the electric vibrating feeders, the sand dewaterers, the sand mixers, together with the mechanical handling equipment in the cement plant, were furnished by The Jeffrey Manufacturing Company of Columbus, Ohio.

OF GENERAL INTEREST

PRIZES AWARDED AT ANNUAL MEETING ON MARCH 18, 1936

The Desmond FitzGerald Medal

Presentation made by Lewis E. Moore, Chairman of Committee on Award

The Desmond FitzGerald Medal was instituted and endowed in 1910 by the late Desmond FitzGerald, a Past President and honorary member of this Society, and is awarded annually for a paper presented to the Society by a member, and published during the year, which is adjudged worthy of special commendation for its merit. The Committee on Award this year, consisting of Lewis E. Moore, Prof. Harry P. Burden, and A. E. Kleinert, selected from the list of a number of excellent papers one which was recommended to the Board of Government for the award. The paper

selected was entitled "Characteristics of Cohesionless Soils Affecting the Stability of Slopes and Earth Fills," by Arthur Casagrande, member, presented at a joint meeting of the Designers and Highway Sections, held on October 2, 1935, and published in the JOURNAL of the Society, January, 1936. On behalf of the Board of Government Mr. Moore presented the Desmond FitzGerald Medal to Arthur Casagrande.

Professor Casagrande expressed his appreciation of the high honor bestowed upon him by the presentation of this medal.

The Sanitary Section Prize

Presentation by Prof. Harry P. Burden, Member of the Sanitary Section Prize Committee

The Committee on Prize Award for the Sanitary Section consisted of Prof. H. P. Burden, E. Sherman Chase and Paul F. Howard. On behalf of the Board of Government, Professor Burden presented the prize to Stanley M. Dore, member, for his paper entitled "Design and Progress on Construction of Dams for Quabbin Reservoir," read

at a meeting of the Sanitary Section on May 1, 1935, and published in the JOURNAL of July, 1935. The prize consisted of books: "Architects' and Builders' Handbook," by Kidder and Parker, and "Waterworks Handbook," by Flinn, Weston and Bogert. Mr. Dore accepted this prize with appropriate remarks.

The Clemens Herschel Prize

Award presented by Vice President Karl R. Kennison

The Clemens Herschel Prize was provided for by the late Clemens Herschel, a Past President and honorary member of the Society. The prize consists of a copy of a book written by the donor and entitled, "Frontinus and the Water Supply of the City of Rome," and is awarded each year for a paper which has been particularly useful and worthy of recognition.

Mr. Kennison, on behalf of the Board of Government, stated that this year the prize had been awarded to Richard S. Holmgren, who presented a paper before the Sanitary Section, October 2, 1935, on "Sewage Disposal Works, Bristol, R. I.," published in the JOURNAL for January, 1936.

1936 FLOOD COMMITTEE OF THE BOSTON SOCIETY OF CIVIL ENGINEERS

Arthur T. Safford of Lowell Heads Committee to Collect Data and to Report on March, 1936, Floods

The importance of obtaining and coordinating all reliable information concerning the floods in March, 1936, affecting so great a territory in the East, and particularly in New England, prompted the Board of Government of the Boston Society of Civil Engineers, at its meeting on April 6, 1936, to authorize the President, Prof. H. K. Barrows, to appoint a Flood Committee for this purpose.

In accordance with that vote, Prof. H. K. Barrows appointed the following committee:

Arthur T. Safford, Engineer, Proprietors of Locks and Canals on Merrimack River, Lowell, Mass., *Chairman*.

Howard M. Turner, Consulting Engineer, Boston, *Vice Chairman*.

S. Stanley Kent, Assistant Engineer, Proprietors of Locks and Canals on Merrimack River, Lowell, Mass., *Secretary*.

H. K. Barrows, Professor of Hydraulic Engineering, Massachusetts Institute of Technology, and Consulting Engineer, Boston.

A. H. Morrill, Acting Chief Engineer, Boston & Maine Railroad, Boston.

Paul L. Bean, Consulting Engineer, Lewiston, Me.

Capt. Hugh J. Casey, Corps of Engineers, United States Engineer Office, Custom House, Boston.

Prof. J. W. Goldthwait, Dartmouth College, Hanover, N. H.

Arthur C. Grover, Rutland, Vt.

R. S. Holmgren, Chief Engineer, New Hampshire Water Resources Board, Concord, N. H.

- H. B. Kinnison, District Engineer, United States Geodetic Survey, Boston.
- W. A. Liddell, Technical Director, National Resources Committee, District 1, Boston.
- Prof. A. C. Lyon, University of Maine, Orono, Me.
- R. R. Marsden, c/o H. J. Lockwood, P. W. A. Engineer, Concord, N. H.
- F. H. Mason, Chief Engineer, New England Public Service Company, Augusta, Me.
- L. G. Morphy, Chief Engineer, Rutland Railroad, Rutland, Vt.
- H. M. Nelson, New England Power Association, Boston.
- William B. Noyes, Public Service Company of New Hampshire, Manchester, N. H.
- W. W. Peabody, Division Engineer, Metropolitan District Water Supply Commission, White Valley, Mass.
- Prof. L. B. Puffer, University of Vermont, Burlington, Vt.
- T. J. Rouner, New England Power Service Company, Boston.
- C. M. Saville, Manager and Chief Engineer, The Water Bureau, Hartford, Conn.
- C. W. Sherman, Metcalf & Eddy, Consulting Engineers, Boston.
- Prof. R. H. Suttie, School of Engineering, Yale University, New Haven, Conn.
- Frank E. Winsor, Chief Engineer, Metropolitan District Water Supply Commission, Boston.
- A. M. Ladd, Hydraulic Engineer, Holyoke Water Power Company, Holyoke, Mass.
- Arthur D. Weston, Chief Engineer, Massachusetts Department of Public Health, Boston.

This committee held an organization meeting in Boston on April 15, 1936, at which a steering committee was appointed to work out plans for a systematic method of collection and compilation of data. This Steering Committee consists of the following: H. M. Turner, *Chairman*, S. S. Kent, *Secretary*, H. B. Kinnison, H. M. Nelson, Allen M. Ladd, William B. Noyes and Major Casey.

The Steering Committee has compiled a list of agencies now collecting data on the flood, in order to prevent the duplication of effort.

This committee desires to receive information of any kind which would be of assistance in its work, and the cooperation of the members of the Society and of others is earnestly sought.

AGENCIES COLLECTING AND COMPILING 1936 FLOOD DATA IN NEW ENGLAND

Data regarding the 1936 flood in New England are being obtained by many agencies, both private and public, covering the hydrology, the snow and ice conditions, flood heights, flows, hydrographs and profiles, maps of flooded areas and estimates of damages. This is being done by power companies, railroads, and the various departments of

cities and towns, counties, States and the Federal government. Most of this material is being compiled by comparatively few agencies from the many sources noted above.

The Flood Committee of the Boston Society of Civil Engineers has assembled the following list of these agencies. This list may not be complete. The Com-

mittee wishes to have it as complete and accurate as possible, and urges every member of the Society to make any additions and corrections that he may have. All communications should be addressed to the Society, attention of the Flood Committee.

In general, local data and data from private sources, such as power companies, are being furnished to one or more of these agencies. In particular, the offices of the United States Geological Survey are obtaining all data from private sources as to the gage heights and river flows, and other data connected with the hydraulics of the flood. The army engineering offices are collecting these also, and in addition the information as to local flood heights, flooded areas and flood damages from State, county, municipal and private sources. The Massachusetts Department of Public Health is compiling the data on the rainfall in Massachusetts, and to some extent in the rest of New England.

NEW ENGLAND — IN GENERAL

United States Geological Survey, Federal Building, Boston. H. B. Kinnison, *District Engineer*.

All data as to river stages, flood flows and hydrographs at United States gaging stations, dams and other points in New Hampshire, Vermont and Massachusetts.

United States Engineer Office, Boston, Mass. Col. John J. Kingman, *District Engineer*; Capt. Hugh J. Casey, *Chief*, Flood Control Division.

Flood control surveys of Merrimack, Salmon Falls, Saco, Androscoggin, Kennebec and Penobscot Rivers, including flood flow, damages and flood control projects.

United States Engineer Office, Providence, R. I. Maj. M. J. Young, *District Engineer*.

Flood control surveys of the Connecticut River and all other area between Hudson and Merrimack River basins.

United States Forestry Service.

Snow surveys, rainfall, flood stage marks.

United States Weather Bureau, Federal Building, Boston. George H. Noyes, *Meteorologist*.

Rainfall, temperature, etc.

National Resources Committee, District 1, Federal Building, Boston.

New England Regional Planning Commission, Federal Building, Boston. Victor M. Cutter, *Chairman*; H. K. Barrows, *Water Resources Consultant*; W. A. Liddell, *Water Resources Technician*.

New England Council, Statler Building, Boston. Dudley Harmon, *Executive Vice President*.

MAINE

United States Geological Survey, State House, Augusta, Me. M. R. Stackpole, *District Engineer*.

All data as to river stages, flood flows and hydrographs at United States gaging stations, dams and other points.

Maine Development Commission, State House, Augusta, Me. Harold F. Schnurle, *Chairman*.

Maine State Highway Department, State House, Augusta, Me. Lucius D. Barrows, *Chief Engineer*.

Maine State Planning Board, State House, Augusta, Me. Edward Chase, *Acting Chairman*; Alfred Mullikin, *Associate Consultant and Director*.

Maine Public Utilities Commission,
State House, Augusta, Me. Mr.
Southard, *Chairman*.

Union Water Power Company, Lewis-
ton, Me. Paul L. Bean, *Engineer*.
Comprehensive flood survey of the
Androscoggin River.

NEW HAMPSHIRE

New Hampshire Flood Reconstruction
Council, Concord, N. H.

Compiling data from all other State
agencies in regard to flood dam-
age.

New Hampshire Forestry and Recrea-
tion Commission, Concord, N. H.

Survey of damage to all public land;
precipitation records and snow
surveys; flood stages in upper
reaches of streams.

New Hampshire Highway Department,
Concord, N. H. Daniel H. Dicken-
son, *Chief Engineer*.

Survey of damage to all roads,
bridges, etc. Flood stages on high-
ways and bridges.

New Hampshire Planning and Develop-
ment Commission, Concord, N. H.
James M. Langley, *Chairman*;
Charles Bowen, *Managing Direc-
tor*.

New Hampshire Public Service Com-
mission, Concord, N. H. Nelson
L. Smith.

Information on damage to utilities,
railroads, etc.

New Hampshire Water Resources
Board, Foster Building, Concord,
N. H. Maj. John Jacobson, Jr.,
Chairman; R. S. Holmgren, *Chief
Engineer*.

Making surveys of areas flooded;
profiles of rivers in New Hamp-
shire; stage and discharge records.

VERMONT

Vermont State Planning Board, State
House, Montpelier, Vt. Frederick
W. Shepardson, *Chairman*; Philip
Shutler, *Associate Consultant*.

Federal Works Progress Administration
Project, Connecticut River Hydro-
logic Survey. Cedric E. Reynolds,
Jr., 6 Gates Street, White River
Junction, Vt.

Hydrologic survey, profiles and
flooded areas.

Vermont State Highway Department,
Montpelier, Vt. H. E. Sargent,
Commissioner and Chief Engineer.

MASSACHUSETTS

Massachusetts Department of Public
Health, State House, Boston. Ar-
thur D. Weston, *Chief Engineer*;
George V. White, *Assistant Engi-
neer*.

Hydrologic data.

Massachusetts Department of Public
Works, 100 Nashua Street, Boston.
William F. Callahan, *Commissioner*;
George H. Delano, *Chief Engineer*.

Damages to highways, bridges, river
banks and dikes.

Massachusetts Geodetic Control Sur-
vey, W. P. A. Project. (Massa-
chusetts Department of Public
Works, sponsor), 100 Nashua Street,
Boston. Elmer C. Houdlette,
Director.

Flood heights, flooded areas and pro-
files.

Massachusetts State Planning Board,
State House, Boston. Elisabeth
M. Herlihy, *Chairman*; Arthur
W. Dean, *Chief Engineer*. Flood
damage.

Massachusetts State Planning Board,
W. P. A. Projects, State House,
Boston. John H. Harding, *Director*.

Massachusetts State Planning Board — *Con.*

Blackstone Valley Flood Control.
Edwin A. Taylor, *Supervisor*, 501
Federal Building, Worcester. Pro-
files and hydrographs.

Connecticut Valley Hydrology. B. A.
Annable, *Supervisor*, 208 Broad-
way, Springfield. Plans, profiles,
hydrographs, stages, discharge of
Connecticut River in Massachu-
setts, Chicopee, Millers, Deerfield
and Westfield Rivers.

Housatonic Valley Flood Control.
A. J. Kohlhofer, Pittsfield, Mass.
Plans, profiles, etc.

Nashua River Survey. Frederick N.
Fowler, Room 10, City Hall,
Leominster, Mass.; Ralph Marble,
Fitchburg. Plans, profiles, etc.

CONNECTICUT

United States Geological Survey, Fed-
eral Building, Hartford, Conn.
B. L. Bigwood, *District Engineer*.

All data as to river stages, flood flows
and hydrographs at United States
gaging stations, dams and other
points.

United States Weather Bureau, Federal
Building, Hartford, Conn. Mr.
Conover, *Meteorologist*.

Gaging stations on Connecticut River
and tributaries.

Connecticut State Planning Board,
State Office Building, Hartford,
Conn. William L. Slate, *Chairman*.

Connecticut State Water Commission,
State Office Building, Hartford,
Conn. George T. Kimball, *Chair-
man*.

PROCEEDINGS OF THE SOCIETY

MINUTES OF MEETINGS

Boston Society of Civil Engineers

DECEMBER 18, 1935. — A regular meet-
ing of the Boston Society of Civil Engi-
neers was held this evening at the Engi-
neers' Club, and was called to order by
the President, John B. Babcock, 3d. One
hundred and twenty members and guests
were present. Eighty-one attended the
buffet supper.

Upon recommendation of the Board of
Government —

Voted, That the Board of Government
be authorized to use the current income
of the Permanent Fund in so far as neces-

sary to meet the current expenses of the
Society.

The President stated that this matter
will be presented at the January 22, 1936,
meeting for final action.

The President then introduced the
speaker of the evening, Mr. Gordon F.
Dodge of the Construction Machinery
Division of the Jeffrey Manufacturing
Company of Columbus, Ohio, who gave a
talk on "The Grand Coulee Dam — The
World's Greatest ConveyORIZED Construc-
tion Project." This huge dam, now being
built on the Columbia River in Washing-
ton, involves the handling of fifteen mil-
lion cubic yards of excavation and four
million cubic yards of concrete. A motion

picture film, "Rivers of Dirt," showed the actual work in progress on this massive project.

The meeting adjourned at 9.30 P.M.

EVERETT N. HUTCHINS, *Secretary*.

JANUARY 22, 1936. — A regular meeting of the Boston Society of Civil Engineers was held this evening at the Engineers' Club, and was called to order by the President, John B. Babcock, 3d, at 7 P.M. There were ninety members and guests present. Previous to the meeting, seventy-one persons attended the buffet supper.

The President stated that at the last meeting of the Society, held on December 18, 1935, a vote was passed regarding the use of the current income of the Permanent Fund. A similar vote is necessary at this meeting; therefore the following vote was passed:

Voted, That the Board of Government be authorized to use the current income of the Permanent Fund in so far as necessary to meet the current expenses of the Society.

The President presented the recommendation of the Board of Government for a proposed amendment to the Constitution to change the age limits of Junior members, the present age limit being 18 to 26, and the proposed limits to be 20 to 28. The proposed reading of Article II, fourth paragraph, first sentence, is as follows:

Juniors shall be not less than twenty years of age, and their connection with the Society shall cease when they become twenty-eight years of age, unless they be previously transferred to another grade.

Voted, That the proposed amendment to the Constitution be adopted.

The President stated that, in accordance with the provisions of the Constitution relative to amendments, this matter will be presented to the membership for letter ballot, which will be canvassed, February 19, 1936.

The President presented, also, amendments to the By-Laws, recommended by

the Board of Government to clarify the matter of payment of dues by Student members and provide that applications from Students be accompanied by a fee of \$3. The proposed reading of the first paragraph of Article 8 is as follows:

8. *Fees and Dues*. — The entrance fee for Members and Associates shall be ten dollars; for Juniors, five dollars; and for Students, three dollars. The entrance fee for Students shall be submitted with the application. A Junior transferred to the grade of Member or Associate shall pay an additional fee of five dollars; a Student transferred to the grade of Junior shall pay an additional fee of two dollars.

The members of any grade, except that of Student, residing within thirty miles of Boston shall be considered as Resident and those beyond that limit as Non-Resident. The annual dues, payable in advance at the annual meeting, shall be as follows: by Resident Members and Associates, ten dollars; by Non-Resident Members and Associates, six dollars; by Resident Juniors, five dollars; by Non-Resident Juniors, four dollars; and by Students, three dollars. There shall be no dues for Students for the period between the date of their election and the next annual meeting. New members, other than Students, elected . . .*

Voted, That the proposed amendments to the By-Laws be adopted.

The President announced that, in accordance with the provisions of the By-Laws relating to amendments, this matter will be finally acted upon at the next regular meeting of the Society on February 19, 1936.

The President reported on the action of the Board of Government in voting as members in favor of the enactment of legislation embodied in House Bill No. 1273, a proposed new building law for Boston, and urged members of the Society to express their views on this matter at legislative hearings.

The President introduced the following speakers, who presented a symposium on "Overcoming Construction Difficulties": Mr. W. G. Cheever, General Manager, Blakeslee-Rollins Corporation, who spoke of problems on the construction of the

* No change beyond this point.

bridge across the Hudson River; A. E. Kleinert, Assistant Structural Engineer, Massachusetts Department of Public Works, who referred to unexpected problems in the progress of construction of the French King Bridge, Weymouth Fore River temporary bridge and other bridges of the Department of Public Works, all of which were solved; S. R. Berke, Chief Engineer of Coleman Bros., who described the work of the Congress Street Bridge in Boston, and several other bridge jobs; Samuel E. Killam, Superintendent of Distribution, Metropolitan Water Division, who described breaks in large water mains, their discovery and repairs under emergency requirements for service, as soon as possible.

Many of these talks were illustrated by lantern slides.

The meeting adjourned at 9.30 P.M.

EVERETT N. HUTCHINS, *Secretary*.

FEBRUARY 19, 1936. — A regular meeting of the Boston Society of Civil Engineers was held this evening at the Engineers' Club, and was called to order by the President, John B. Babcock, 3d, at 7 P.M.

The President reported the result of the letter ballot canvassed today on the adoption of the amendment to the Constitution to change the age limit of Junior members, as follows: total number of ballots cast, 251; Yes, 245; No, 2; blanks, 4. The President then declared that the amendment, which was first voted upon at the last meeting, January 22, 1936, and now voted upon by letter ballot, has been adopted in Article 11, fourth paragraph, first sentence, to read as follows:

Juniors shall be not less than twenty years of age, and their connection with the Society shall cease when they become twenty-eight years of age, unless they be previously transferred to another grade.

The President also stated that at the last meeting of the Society, January 22, 1936, the Society voted to adopt certain amendments to the By-Laws which

would clarify the matter of the payment of dues of Students and provide that applications from Students be accompanied by an Entrance Fee of \$3. The proposed reading, Article 8, first paragraph, is as follows:

8. *Fees and Dues.* The entrance fee for Members and Associates shall be ten dollars; for Juniors, five dollars; and for Students, three dollars. The entrance fee for Students shall be submitted with the application. A Junior transferred to the grade of Member or Associate shall pay an additional fee of five dollars; a Student transferred to the grade of Junior shall pay an additional fee of two dollars.

The members of any grade, except that of Student, residing within thirty miles of Boston shall be considered as Resident and those beyond that limit as Non-Resident. The annual dues, payable in advance at the annual meeting, shall be as follows: by Resident Members and Associates, ten dollars; by Non-Resident Members and Associates, six dollars; by Resident Juniors, five dollars; by Non-Resident Juniors, four dollars; and by Students, three dollars. There shall be no dues for Students for the period between the date of their election and the next annual meeting. New members, other than Students, elected . . .*

Voted, That the proposed amendments to the By-Laws be adopted.

This is the second and final action on this matter.

The President then introduced Mr. Frank P. Cartwright, member of the Engineering Staff, National Lumber Manufacturers Association, Washington, D. C., who gave an interesting talk on "Recent Developments in the Use of Timber in Engineering Construction."

Mr. Cartwright pointed out revisions in the traditional concepts of design and erection of timber structures through the improvement in the efficiency of the joint, thus opening broader opportunities for the use of timber for such structures as roof trusses, radio towers, tank towers, oil derricks, bridges, wharves, falsework and shoring.

The talk was illustrated with lantern slides.

* No change beyond this point.

Eighty-one members and guests attended this meeting, and sixty-five persons attended the buffet supper prior to the meeting.

The meeting adjourned at 9 P.M.

EVERETT N. HUTCHINS, *Secretary*.

MARCH 18, 1936. — The eighty-eighth annual meeting of the Boston Society of Civil Engineers was held today at the Boston Chamber of Commerce, and was called to order by the President, John B. Babcock, 3d, at 5 P.M.

The minutes of all previous meetings of the year which have been printed in the various issues of the JOURNAL were declared approved as printed.

The President announced the deaths of the following members:

Charles R. Berry, who died on February 24, 1936, and had been a member since September 16, 1914; Ernest W. Branch, who died on March 8, 1936, and had been a member since May 19, 1897; Charles Mills, who died on March 4, 1936, and had been a member since February 16, 1887; Joseph A. Tomasello, who died February 21, 1936, and had been a member since January 24, 1917.

The annual reports of the Board of Government, Treasurer, Secretary and Auditors were presented. Reports were also made by the following committees: Social Activities, Relation of Sections to Main Society, Welfare, Library, and John R. Freeman Fund.

Voted, That the reports be accepted with thanks and placed on file, and that they be printed in the April, 1936, JOURNAL.

Voted, That the incoming Board of Government be authorized to appoint such committees as it deems desirable.

The report of the Tellers of Election, Waldo F. Pike and Charles L. Coburn, was presented, and in accordance therewith the President declared the following had been elected officers for the ensuing year:

President — Prof. Harold K. Barrows.
Vice-President (for two years) — Karl R. Kennison.

Secretary — Everett N. Hutchins.

Treasurer — Charles R. Main.

Directors (for two years) — Arthur Casagrande, Athole B. Edwards.

Members of Nominating Committee (for two years) — James F. Brittain, Samuel M. Ellsworth, LeRoy M. Hersum.

The retiring President then delivered his annual address on "The Boston Society of Civil Engineers and its Founder Members."

The meeting adjourned, to assemble at 7.30 P.M., the annual dinner being held during the interim.

The President then called the meeting to order for the presentation of prizes.

He requested Lewis E. Moore, Chairman of the Committee on Award of the Desmond FitzGerald Prize, to present the Desmond FitzGerald Medal to Arthur Casagrande, member, for his paper on "Characteristics of Cohesionless Soils Affecting the Stability of Slopes and Earth Fills," presented at a joint meeting of the Designers and Highway Sections, held on October 2, 1935, and published in the January, 1936, JOURNAL.

The President called upon Prof. Harry P. Burden, Chairman of the Sanitary Section Prize Committee, to present the Sanitary Section Prize to Stanley M. Dore, member, for his paper on "Design and Progress on Construction of Dams for Quabbin Reservoir," presented at a meeting of the Sanitary Section, held on May 1, 1935, and published in the July, 1935, JOURNAL. The prize consisted of books: "Waterworks Handbook," by Flinn, Weston and Bogert, and "Architects' and Builders' Handbook," by Kidder and Parker. The President requested the 12 of the 21 living Past Presidents of the Society, who attended the dinner, to stand as their names were called. The Senior Past President, Senior Member of the Society, and Honorary Member, Prof. C. Frank Allen, very appropriately gave some reminiscences. The newly elected President, Prof. Harold K. Barrows, upon being presented, made appropriate remarks.

A program of entertainment, including music, comedy sketches, dancing and magic, concluded the program of the evening.

Eighty-nine members and guests attended the dinner.

The meeting adjourned at 10 o'clock.

EVERETT N. HUTCHINS, *Secretary*.

Sanitary Section

FEBRUARY 5, 1936. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held February 5, 1936. Preceding the meeting, dinner was enjoyed at Patten's, with thirty members and guests present.

The meeting was called to order at 6.50 P.M. in the rooms of the Society, with seventy-five members and guests present.

The following members were elected as a Nominating Committee, to submit a list of officers for the coming year at the annual meeting in March: George C. Bogen, Francis H. Kingsbury, Stuart E. Coburn.

Mr. Gail P. Edwards, Laboratory Coordinator, Engineering Division, Massachusetts Department of Public Health, spoke on the subject, "Sanitary Conditions in Boston Harbor." He outlined the work carried on by the "Special Commission on Boston Harbor Investigation" during the past summer in studying the sanitary conditions of the harbor. This work included the taking of a large number of samples at numerous places in the harbor for analysis, the study of currents by floats, and modern settling and screening plants at the various major outfalls, to determine the content of solids, ammonia and nitrogen in the sewage being discharged. An interesting discussion followed.

The meeting adjourned at 8.30 P.M.

RICHARD S. HOLMGREN, *Clerk*.

MARCH 4, 1936. — The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held March 4, 1936. Preceding the meeting, the members assembled at Patten's restaurant and enjoyed dinner together. There were ten members present.

The meeting was called to order at 7.15 P.M. in the rooms of the Society, with fifteen members present.

The report of the Executive Committee for the past year was read and accepted.

The report of the Nominating Committee for officers for the following year was submitted as follows:

Chairman — Paul F. Howard.
Vice-Chairman — Richard S. Holmgren.
Clerk — Ralph M. Soule.
Executive Committee — Frank L. Flood,
Gail P. Edwards, Samuel M. Ellsworth.

No further nominations were offered, and the Secretary was instructed to cast one ballot for the election of the officers as named by the Nominating Committee. This was duly done.

No further business appearing, the Section adjourned at 7.45 P.M., in order to permit the members to attend a meeting of the Engineering Societies of New England devoted to aviation.

RICHARD S. HOLMGREN, *Clerk*.

Designers Section

FEBRUARY 26, 1936. — This meeting of the Designers Section was held jointly with the Highway Section at the Society rooms, 715 Tremont Temple, and was called to order at 6.40 P.M.

The Chairman called for nominations from the floor for a nominating committee of three members to submit nominations at the next meeting for officers to serve during the ensuing year. There being no nominations from the floor, upon motion, duly seconded, it was —

Voied, That the Chairman appoint a nominating committee of three members of the section to prepare and present at the meeting of March 11, 1936, a list of nominations for officers for the ensuing year.

Chairman Brask then appointed the following members on the nominating committee: Frederic N. Weaver, Chairman, LeRoy M. Hersum, Albert E. Kleinert.

There being no further business, the meeting was turned over to the Chairman of the Highway Section, who introduced the speaker, Mr. Albert E. Kleinert of the Massachusetts Department of Public Works, who spoke on "The Design and Construction of the Quincy-Weymouth Fore River Bridge." The talk was illustrated with plans and pictures, and was followed by a period of discussion.

The meeting closed at 9 P.M., with a joint attendance of sixty.

ANTHONY S. COOMBS, *Clerk*.

MARCH 11, 1936. — The annual meeting of the Designers Section was held on March 11, 1936, at the Society rooms, being called to order by Chairman Brask at 6.35 P.M.

The annual report for the past year, submitted by the Clerk, for the Executive Committee, was read and accepted.

The Nominating Committee appointed at the meeting held February 26, 1936, submitted its report, a copy of which is filed with these records. The nominations as made by the nominating committee were —

Chairman — Albert Haertlein,
Vice-Chairman — Herman G. Dresser.
Clerk — Anthony S. Coombs.
Executive Committee — John B. Wilbur,
J. Donald Mitsch, Arthur S. Harding.

There were no nominations made from the floor, and on motion duly seconded it was —

Voted, That the nominations be closed.
On motion duly seconded it was —

Voted, That the Clerk cast one ballot for the officers proposed by the Nominating Committee.

The Clerk cast one ballot as directed, and those nominated were declared elected.

There being no further business, the speaker presented Mr. Herman G. Dresser, Vice-Chairman elect, who spoke on the subject "Some Design Features of Pipe and Concrete Sewers and Culverts." This talk was illustrated with the reflectoscope, and covered various methods used in the design of sewers and similar structures, especially for the resistance of external loads.

The meeting adjourned at 8.00 P.M., with an attendance of twenty-seven.

ANTHONY S. COOMBS, *Clerk*.

Highway Section

FEBRUARY 26, 1936. — A meeting of the Highway Section of the Boston Society of Civil Engineers was held jointly with the Designers Section on February 26,

1936, at the Society rooms in Tremont Temple.

The meeting was called to order at 6.40 P.M. by the Chairman of the Highway Section, Mr. George A. Graves.

This being the annual meeting of the Highway Section, the first business to come before the meeting was the election of officers of the section for the ensuing year. The nominating committee, appointed at a previous meeting, submitted its report.

The Nominating Committee submitted the following nominations:

Chairman — Henry B. Alvord.
Vice-Chairman — Alexander J. Bone.
Clerk — T. C. Coleman.
Executive Committee — Arthur B. Appleton, William P. Morse, Clarence P. Taylor.

No further nominations were submitted.

It was then voted that the nominations be closed.

It was voted that the Clerk be instructed to cast one ballot for the officers submitted by the nominating committee. This being done, the chairman declared the above-named persons as elected.

The members of the Highway Section took a short recess for the purpose of permitting the Chairman of the Designers Section to make an announcement to the members of that section.

Mr. A. E. Kleinert of the Massachusetts Department of Public Works presented a paper on "The Design and Construction of the Quincy-Weymouth Fore River Bridge." The talk was illustrated by photographs taken during the progress of the work, and the speaker gave an interesting and instructive description of the difficulties encountered and the manner in which they were overcome, as was shown by the lively manner in which the audience took part in the question period following the meeting.

There were sixty members of the Society and affiliated societies present at the meeting.

The meeting adjourned at 9 P.M.

T. C. COLEMAN, *Clerk*.

Northeastern University Section

JANUARY 16, 1936. — The Northeastern University Section of the Boston Society of Civil Engineers met on Thursday, January 16, 1936, in Room 40 of the Huntington Building.

The meeting was called to order by Vice-Chairman G. Albion Smith, at 7.30 P.M. He introduced the speaker of the evening, Mr. E. T. Hartman, Planning Consultant for the State Department of Public Welfare. Mr. Hartman spoke on the relation of planning to civil engineering, stressing the social aspects.

Refreshments were served during the informal question period following the talk.

There were fifteen members and guests present.

The meeting adjourned at 9.30 P.M.

LESTER S. PERRY, *Vice-Clerk*.

FEBRUARY 18, 1936. — A meeting of the Northeastern University Section of the Boston Society of Civil Engineers was held in Room 18H, at Northeastern, on Tuesday, February 18, 1936. The meeting was preceded by a dinner at Putnam's Café, at which thirty were present.

Chairman Dallas called the meeting to order at 7.15 P.M. The minutes of the December 13, 1935, meeting were read and approved and a nominating committee appointed by the Chair. This Committee was composed of E. L. Spencer, Chairman, W. A. Grady and M. P. Craven.

Mr. Maxwell Halsey, Assistant Director of the Bureau for Traffic Research at Harvard University, was the speaker. He gave a most interesting and instructive résumé of modern methods of traffic control. A long and lively discussion period followed the talk in which Professor Alvord of Northeastern University and Chief of Police Wilson of Wichita, Kansas, took leading and diversified parts.

The meeting was not adjourned till 10.15 P.M. Attendance, forty-two.

FRANCIS J. FLYNN, *Clerk*.

APPLICATIONS FOR MEMBERSHIP

[April 1, 1936]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of fifteen (15) days from the date given.

For Admission

CULLITY, MARTIN JOSEPH, Jr., Arlington, Mass. (Age 27, b. Boston, Mass.) Attended three and one half years high school, Providence, R. I.; university extension courses in estimating costs and quantities on highway bridges and buildings, receiving certificate; special courses in building costs and engineering construction at Massachusetts Institute of Technology, 1933; at present in third year of civil engineering, Lincoln Technical Institute (evening courses) of Northeastern University. Experience: 1925-33, several periods with G. T. Daley & Co., Inc., of Springfield, Mass., in various capacities on large transmission lines, timekeeper's clerk, rope rigger, form carpenter, material man, timekeeper and cost clerk; also, various periods with New England Power Engineering and Service Corporation on general construction work and

general foreman, blasting, pole location and construction; November, 1933, to February, 1935, general foreman with Hugh Nawn Inc., of Boston, intermittently, blasting, clearing right of way, etc.; experience as foreman includes construction of underground electric light and power systems for street lighting, street and sidewalk resurfacing, erection of poles and towers for transmission lines, blasting under congested conditions, and reconstruction of high pressure gas main system; also, has done estimating on small bridges and small projects for himself. Refers to *C. R. Bliss, E. A. Dow, C. M. Durgin, E. G. Lee, C. H. Smith.*

CUSTANCE, ADIN MILLARD, Hudson, Mass. (Age 45, b. Braintree, Mass.) Graduate of Dean Academy, 1909; Worcester Polytechnic Institute, two years in civil engineering; graduate, International Correspondence School in Municipal Engineering; civil service as civil engineer, draftsman and foreman inspector highways; United States civil service, senior highway construction supervisor. Experience: 1910-14, four seasons with Hassam Paving Company on State road work in New York and New Jersey as timekeeper, inspector, foreman and assistant superintendent, laying Hassam pavements, sheet asphalt, drains, culverts, etc.; five and one half years as resident engineer for Massachusetts Highway Commission in charge of maintenance and construction on State highways; 1920-25, as superintendent of public works, Hudson, Mass., in charge of maintenance, design and construction of water distribution, streets and sewers, pumping station; nine years in general contracting, building State roads and bridges, private building and heavy concrete work; also, operation of commercial washed sand and gravel plant; sixteen months as non-relief civil engineer supervisor C. W. A. and E. R. A. park department projects in Hudson; May to December, 1935, resident engineer P. W. A., in charge of street construction in New Bedford; December, 1935, to present, resident engineer inspector P. W. A. in charge of water tank, Millis, Mass., and street and sewer job in Walpole, Mass. Refers to *E. R. B. Al-*

lardice, F. W. Bateman, W. G. Classon, R. W. Coburn, A. W. Dean, G. H. Nye.

DITTAMI, FRANCIS RANDOLPH, West Medford, Mass. (Age 22, b. New York, N. Y.) Graduated Tufts College, 1935, with degree of B.S. in civil engineering, magna cum laude. August to September, 1934, cost and efficiency man on ledge excavation, with B. Perini & Sons, Inc., Framingham, Mass.; for Boston-Concord road at Lincoln; June to December, 1935, with same company as timekeeper on the Bills Brook Dam at New Hartford, Conn.; January, 1935, appointed senior engineer (non-relief) with W. P. A. project on re-determination of street lines in Medford, Mass. Refers to *R. Abbott, H. P. Burden, S. L. Conner, F. N. Weaver.*

GEER, DAVID SMITH, Boston, Mass. (Age 29, b. Galion, Ohio.) Graduated from high school, Galion, Ohio, 1924; 1925 to 1929 at Carnegie Institute of Technology, studied structural engineering and architecture. Since spring of 1930 has been with following organizations in Boston and New York: S. Bruce Ellwell and Geo. E. Robinson, architects, 1930; Charles G. Loring, architect, 1931-33; Beatrix Farrand, landscape architect, 1933; Boston City Planning, E. R. A. project, 1933; Boston Mayor's Committee to reorganize Engineering Departments, 1934; in 1934 studied city planning at Massachusetts Institute of Technology; during 1935 was in charge of transportation studies of New England Regional Planning Commission; now in charge of transportation planning studies of Massachusetts State Planning Board. Refers to *J. B. Babcock, 3d, A. W. Dean, J. H. Harding, M. Linenthal.*

MONIER, EDWARD A., West Medford, Mass. (Age 27, b. Cambridge, Mass.) Graduated from Medford High School, 1927; fall of 1927 attended Tufts College, taking civil engineering as major course, receiving degree in same, March, 1933. June to September, 1931, transitman, Commonwealth of Massachusetts on construction; December, 1933, to April, 1934, on C. W. A. for Massachusetts Department of Public Safety; since April, 1935, with city of Medford as transitman, inspector on survey and construction.

Refers to *R. Abbott, H. P. Burden, S. L. Conner, F. N. Weaver.*

WALSH, JAMES H., Jr., Brighton, Mass. (Age 32, b. Cambridge, Mass.) Attended Rindge Technical School, 1917-22; Tufts Engineering School, 1922-26, receiving B.S. in civil engineering. From 1926 to present time, with Walsh Brothers, general contractors, in various capacities, ranging from engineering to construction superintendent; also, experience in estimating. Refers to *R. Abbott, H. P. Burden, S. L. Conner, F. N. Weaver.*

WRIGHT, HARRY I., Belmont, Mass. (Age 51, b. Westborough, Mass.) Attended Brockton High School, Franklin Union, Lowell Institute Mechanical Engineering Course and took six advance courses. Sixteen years as designer with L. E. Knott Apparatus Company; three years with Stone & Webster on piping design; one year with General Radio, as designer on special navy compensators; one year as designer on special machinery for technicolor; from 1930 to present time with town of Belmont on streets and sewers, in engineering office. Refers to *J. W. Kales, G. E. Russell, D. M. Wood, J. L. Woodfall.*

For Transfer from Grade of Junior

GAWLOWICZ, MITCHELL WALTER, New Bedford, Mass. (Age 30, b. Lowell, Mass.) Attended Worcester Polytechnic Institute from September, 1923, to June, 1927; 1927 to date, employed by Massachusetts Department of Public Works as engineer successively from grade I to the present grade III; June, 1927, to fall of 1928, in office as draftsman, designer, estimator; fall of 1928 to spring of 1929, in field on construction as first assistant to resident engineer; spring of 1929 to date, in field with survey party as rodman and instrumentman; from November, 1930, chief of party. Refers to *A. B. Appleton, T. C. Coleman, G. A. Graves, E. N. Hutchins, J. W. Lymberg.*

For Transfer from Grade of Student

BAUER, WILLIAM RAHN, New Bedford, Mass. (Age 26, b. Pottstown, Pa.) Graduated from Northeastern University in 1934, with degree of B.S. in civil engi-

neering (five-year course). While at Northeastern University, employed for short periods by Frank M. Metcalf, civil engineer, during 1931, 1934 and 1935; June 19 to August 31, 1934, with United States Army Engineers on triangulation work for fire control stations for Fort Rodman, New Bedford, Mass.; October 4, 1934, to March 22, 1935, rodman and transitman on E. R. A. projects sponsored by city building department, New Bedford, Mass.; September 4, 1935, to date, junior engineer on E. R. A. and W. P. A. planning work for building department, New Bedford, Mass. Refers to *H. B. Alword, C. O. Baird, A. E. Everett, G. H. Nye.*

For Transfer from Junior to Grade of Member

TRAVERS, IRVING ROBERT, Roxbury, Mass. (Age 32, b. Boston, Mass.) Attended Northeastern University, 1922-24; 1925, rodman and engineering assistant, Massachusetts Department of Public Works; graduate, George Washington University in 1928; 2d Lieutenant, Corps of Engineers, on construction; chief of party, United States Coast and Geodetic Survey, 1931-32; District of Columbia Engineering Department, on triangulation, 1932 and 1933; 1934, construction foreman, building C. C. C. camps and roads; 1935, United States Geodetic Survey; 1936, private engineering office. Refers to *H. B. Frye, J. H. Harding, A. E. Haskell, H. B. Kinnison, E. O. Stearns.*

For Transfer from Student to Grade of Junior

KELLEY, CHARLES MERRILL, Revere, Mass. (Age 24, b. Boston, Mass.) Graduated from Boston English High School; attended Northeastern University, December, 1930, to June, 1936; awarded degree of B.S. in civil engineering, "with honor." Employed since October 1, 1935, as Junior Engineering Aide in the Highway Division of the Massachusetts Department of Public Works; during the winter on survey work. At present timekeeper and office assistant with Merritt, Chapman & Scott, Contractors, Boston. Refers to *H.*

B. Alvord, A. B. Appleton, C. O. Baird, C. S. Ell, F. H. Fay.

KENDALL, IRVING W., Stoughton, Mass. (Age 24, b. Stoughton, Mass.) Graduated from Northeastern University, June, 1935, with degree B.S. in civil engineering. Since April, 1935, employed by town of Stoughton engineering department on surveying, drafting and other engineering work. Refers to *H. B. Alvord, C. O. Baird, C. S. Ell, A. E. Everett.*

ADDITIONS

Members

MALCOLM P. CANTERBURY, 230 Park Street, West Roxbury, Mass.
 ELLIOT F. CHILDS, 520 Lexington Street, Waltham, Mass.
 JOHN T. DONAHOE, 56 Monroe Street, Brooklyn, N. Y.
 HOWARD T. EVANS, 29 Cottage Street, Wellesley, Mass.
 ALBERT E. EVERETT, 4 Crown Street, Auburndale, Mass.
 JOHN W. GREENLEAF, Jr., 313 Allston Street, Brighton, Mass.
 JOHN H. LOWE, 159 Williams Avenue, Lynn, Mass.
 RALPH A. MARBLE, 336 Main Street, Fitchburg, Mass.
 AUSTIN B. MASON, Church Street, Weston, Mass.
 GERALD PUTNAM, 165 Gray Street, Arlington, Mass.
 CHARLES S. RICHARDSON, 30 Lewis Street, East Lynn, Mass.
 PHILIP C. RUTLEDGE, 8 Craigie Circle, Cambridge, Mass.
 RALPH M. SOULE, 124 Walnut Street, Braintree, Mass.

Juniors

ROBERT R. BALMER, Jr., 17 Eden Street, Salem, Mass.
 REGINALD A. BARRON, 205 East Main Street, Branford, Conn.

WALTER E. BUTLER, 14 Kane Street, New Bedford, Mass.

GEORGE W. JENNESS, Box 87, Hanover, Mass.

LINCOLN W. RYDER, 17 Winthrop Avenue, Wollaston, Mass.

Students

ANTONIO BAGLIONE, 7 Savoy Street, Boston, Mass.
 FELIX J. CHLUDZINSKI, 844 Dorchester Avenue, Dorchester, Mass.
 FLAVIANO CIFELLI, 22 Leavitt Street, Brockton, Mass.
 MICHAEL J. COLARUSSO, 61 Derby Street, Somerville, Mass.
 JOHN H. CORCORAN, 353 Concord Avenue, Cambridge, Mass.
 WILLIAM G. DYER, 20 Elmwood Avenue, South Braintree, Mass.
 HABEEB M. HANNA, 521 Shawmut Avenue, Boston, Mass.
 JAMES KLINE, 34 Estella Street, Dorchester, Mass.
 HELMUT J. KNOLL, 29 Central Street, East Dedham, Mass.
 WILLIAM H. MITCHELL, 28 Spaulding Street, Dorchester, Mass.
 CHARLES A. PERKINS, Oak Hill Road, Harvard, Mass.
 LAWRENCE M. PETERSON, Willow Street, South Hamilton, Mass.
 LEWIS W. POLLARD, 61 St. Mark's Road, Dorchester, Mass.
 RICHARD A. WIRLING, 2 Raymond Avenue, Beverly, Mass.
 EDWARD J. ZAICHUK, 43 Munroe Street, Somerville, Mass.

DEATHS

CHARLES R. BERRY	Feb. 24, 1936
ERNEST W. BRANCH	Mar. 8, 1936
ALBERT B. DRAKE	Sept. 26, 1935
CARL H. M. JOHNSON	June 27, 1935
CHARLES MILLS	Mar. 4, 1936
JOSEPH A. TOMASELLO	Feb. 21, 1936

ANNUAL REPORTS

Report of Board of Government for the Year 1935-36

BOSTON, MASS., March 18, 1936.

To the Boston Society of Civil Engineers:

Pursuant to the requirements of the By-Laws, the Board of Government presents its report for the year ending March 18, 1936.

Membership

Sixteen new members, 5 juniors and 32 students have been added during the year, and 3 members and 1 junior have been reinstated, making a total addition of 57 members.

During the year 14 members have died, 10 have resigned, 29 members have had dues remitted and resignations accepted, 101 members have been dropped for non-payment of 1935 dues, 26 members have been dropped for non-payment of 1936 dues, and 23 students have been dropped on account of failure to transfer to a higher grade, making a total deduction of 203.

The present net membership of the Society consists of 5 honorary members, 624 members, 75 juniors, 73 students, 9 associates, 1 member of Sanitary Section, making a total membership of 787, a net loss for the year of 151.

The honorary membership list now is as follows:

Charles T. Main, elected January 28, 1932.
Dr. Karl T. Compton, elected February 17, 1932.
Prof. C. Frank Allen, elected March 16, 1932.
Harrison P. Eddy, elected February 21, 1934.
Joseph R. Worcester, elected February 21, 1934.

Deaths

Members:

Charles R. Berry, February 24, 1936.
William W. Bigelow, October 4, 1935.
Ernest W. Branch, March 8, 1936.
Nathan S. Brock, July 11, 1935.
Alfred E. Burton, May 11, 1935.
Albert B. Drake, September 26, 1935.
Fayette F. Forbes, November 20, 1935.
X. H. Goodnough, August 10, 1935.
Charles Mills, March 4, 1936.
John E. Palmer, May 11, 1935.
James W. Rollins, November 19, 1935.
Frank C. Shepherd, August 8, 1935.

Associate:

Joseph A. Tomasello, February 21, 1936.

Student:

Carl H. M. Johnson, June 27, 1935.

Remission of Dues and Extension of Time

The membership of the Society has been subject during recent years to the effects of the depression. During this period the Board of Government has granted a number of members an extension of time for payment of dues and has remitted the dues of other members. With much regret the Board voted this year to drop from membership those who had not paid their 1935 dues for which an extension had been granted; this action was taken only for those who had not replied to several communications from the Board requesting information as to their circumstances. The Board has remitted dues and accepted resignations from 29 members who communicated with the Secretary and realized the justice of such a step. In the case of 4 members, dues for the year ending March 18, 1936, have been remitted.

The Board has granted 62 members an extension of time for payment of dues for year ending March 18, 1936.

Exemption of Dues

Eighty-two members are now exempt from dues in accordance with By-Law 8, which provides that "a member of any grade who has paid dues for forty years, or who has reached the age of seventy years and has paid dues for thirty years, shall be exempt from further dues."

Meetings of the Society

Eight regular meetings, since the Annual Meeting, have been held during the year, and an outing on June 22 was held at Salem Willows.

The average attendance at the meetings of the Society was 97, the largest being 160 and the smallest 40. Buffet suppers have been a feature of all the meetings. The papers and addresses given were as follows:

March 21, 1935. — Annual meeting. Address of retiring President, Arthur T. Safford, "Merrimack Valley Hydraulic Engineers," followed by dinner, smoker and entertainment.

April 17, 1935. — "Scope and Accomplishments of the C. C. C. Camps in Massachusetts," by Lieut. Col. Stuart A. Godfrey, Engineer, 1st Corps Area, and Egbert Hans, Landscape Architect, Massachusetts Department of Conservation.

May 15, 1935. — "Some Engineering Features of the Modern Racing Yachts," by Prof. George Owen, Professor of Naval Architecture, Massachusetts Institute of Technology.

June 22, 1935. — An inspection trip, made jointly with the Sanitary Section of the Society, to the new Salem and Beverly Water Treatment Plant at Wenham Lake, Beverly, followed by an outing at Salem Willows.

September 25, 1935. — "The Engineering and Construction Features of the Suffolk Downs Race Track," by Mark Linenthal, Consulting Engineer; George A. Crane, Treasurer of Temple & Crane, Inc., Contractors; A. B. MacMillan, Chief Engineer, Aberthaw Company; Joseph A. Tomasello, President and Treasurer, A. G. Tomasello & Son, General Contractors.

October 16, 1935. — "Wire Rope," by J. F. Howe and B. N. Carlson, American Steel and Wire Company, Worcester, Mass.; "Random Notes on Cable Engineering," by Thomas F. Peterson, Consulting Cable Engineer, American Steel and Wire Company, Worcester, Mass.

November 21, 1935. — "Sun's Effects on Human Affairs," by Dr. Harlan T. Stetson, Research Associate in Geophysics, Harvard University.

December 18, 1935. — "The Grand Coulee Dam — the World's Greatest Conveyorized Construction Project," by Gordon F. Dodge, Construction Machinery Division of The Jeffrey Manufacturing Company, Columbus, Ohio.

January 22, 1936. — Symposium, "Overcoming Construction Difficulties," by W. G. Cheever, General Manager, Blakeslee, Rollins Corporation; A. E. Kleinert, Assistant Structural Engineer, Massachusetts Department of Public Works; S. R. Burke, Chief Engineer, Coleman Bros.; S. E. Killam, Superintendent Distribution Section, Metropolitan District Commission.

February 19, 1936. — "Recent Developments in the use of Timber in Engineering Construction," by Frank P. Cartwright, Member of Engineering Staff of National Lumber Manufacturers Association and of the Timber Engineering Company, Washington, D. C.

Sections

Nineteen meetings were held by the Sections of the Society during the year. These meetings of the Sections, offering opportunity for less formal discussion, have continued to demonstrate their value to their members and to the Society. The variety of subjects presented has made an appeal to the members, as indicated by the general attendance at these meetings.

Sanitary Section Meetings. — The Sanitary Section has held 5 meetings during the year, with an average attendance of 46. The papers and meetings are listed in the report of the executive committee. Present membership, 179.

Designers Section Meetings. — The Designers Section has held 8 regular meetings during the year. The average attendance has been 59. The papers and meetings are listed in the report of the executive committee. Present membership, 164.

Highway Section Meetings. — The Highway Section has held 3 regular meetings during the year, with an average attendance of 76. Present membership, 96.

Northeastern University Section. — The Northeastern University Section has held 6 meetings during the year, with an average attendance of 36. Present total membership, 216, of which 52 are in attendance at the University.

Journal

The complete report of the Editor of the Journal for the calendar year 1935 will be printed in the April JOURNAL.

*Funds of the Society **

Permanent Fund. — The Permanent Fund of the Society has a present value of about \$50,000. The Society again authorized the use of as much as necessary of the current income of this fund in payment of current expenses.

John R. Freeman Fund. — In 1925 the late John R. Freeman, a Past President and honorary member of the Society, made a gift to the Society of securities which was established as the John R. Freeman Fund, the income from which was about \$1,300. The income from this fund is to be particularly devoted to the encouragement of young engineers. Mr. Freeman suggested several uses, such as the payment of expenses for experiments and compilations to be reported before the Society; for underwriting meritorious books or publications pertaining to hydraulic science or art; or a portion to be devoted to a yearly prize for the most useful paper relating to hydraulics contributed to this Society; or establishing a traveling scholarship every third year open to members of the Society for visiting engineering works, reports of which would be presented to the Society.

* Details regarding the values and income of these funds are given in the Treasurer's report.

Edmund K. Turner Fund. — In 1916 the Society received 1,105 books from the library of the late Edmund K. Turner and a bequest of \$1,000, "the income of which is to be used for library purposes." The Board voted to use as much of the income as is available for the purchase of books for the library.

Alexis H. French Fund. — The Alexis H. French Fund, a bequest amounting to \$1,000, was received in 1931 from the late Alexis H. French of Brookline, a former Past President of the Society. The income of this fund is "to be devoted to the library of the Society." The Board voted to use a portion of the available income for the purchase of books for the library and a part for permanent binding of certain periodicals.

Desmond FitzGerald Fund. — The Desmond FitzGerald Fund, established as a bequest from the late Desmond FitzGerald, a Past President and honorary member of the Society, provides that the income from this fund shall "be used for charitable and educational purposes." The Board voted on January 23, 1935, to appropriate from the income from this fund the sum of \$100, to be known as the Boston Society of Civil Engineers Scholarship in memory of Desmond FitzGerald, and to be given to a student of Northeastern University. Presentation of this scholarship was made by President John B. Babcock at a student meeting of the University in May, 1935, to Kenneth F. Knowlton, a senior student in civil engineering. This year on January 22, 1936, the Board voted to award a scholarship which will be presented to the selected student at a special meeting of the students to be held at an early date at the University.

Tinkham Memorial Fund. — The "Samuel E. Tinkham Fund," established in 1921 at the Massachusetts Institute of Technology by the Society "to assist some worthy student of high standing to continue his studies in civil engineering," had a value of \$2,459.39 on June 29, 1935. Mr. Ariel A. Thomas, of Woonsocket, R. I., a student in civil engineering in the class of 1936 at Technology, has been awarded this scholarship for the year 1935-36.

Clemens Herschel Fund. — This fund was established in 1911 by a bequest from the late Clemens Herschel, a former Past President and honorary member of the Society. The income from this fund is to be used for the presentation of prizes for particularly useful and commendable papers presented at meetings of the Society. The present value of this fund is about \$1,000. The expenditure made during the year from this fund was for prizes.

Edward W. Howe Fund. — This fund, a bequest of \$1,000, was received December 2, 1933, from the late Edward W. Howe, a former Past President of the Society. No restrictions were placed upon the use of this money, but the recommendation of the Board of Government is that the fund be kept intact, and that the income be used for the benefit of the Society or its members. No expenditure was made during the year.

Desmond FitzGerald Medal

The Desmond FitzGerald Medal (bronze) was provided for in 1910 as an endowed prize by the late Desmond FitzGerald, a former Past President and honorary member of the Society. The prize is awarded annually to a member who presents an original paper to the Society which is published in the JOURNAL for the current year.

In accordance with the recommendation of the Committee on Awards, the Board of Government voted to award the Desmond FitzGerald medal to Arthur Casagrande, member, for his paper on "Characteristics of Cohesionless Soils affecting the Stability of Slopes and Earth Fills," presented at a joint meeting of the Designers and Highway Sections held on November 13, 1935, and published in the JOURNAL for January, 1936.

Section Prizes

The Board of Government voted on April 12, 1924, "to present a prize for a worthy paper given in each section by a member of that section," this award to consist of books suitably inscribed.

Sanitary Section Prize.— The Board adopted the recommendation of the Sanitary Section Prize Committee, and voted that the Sanitary Section Prize be awarded to Stanley M. Dore, member, for his paper on "Design and Progress on Construction of Dams for Quabbin Reservoir," presented at a meeting of the Sanitary Section on May 1, 1935, and published in the July, 1935, JOURNAL. The prize consisted of "Waterworks Handbook," by Flinn, Weston and Bogert, and "Architects' and Builders' Handbook," by Kidder and Parker.

Clemens Herschel Award

The late Clemens Herschel, a former Past President and honorary member, gave to the Society a number of copies of his book on "Frontinus and the Water Supply of the City of Rome," with the request that the Board award one or more of the books each year as prizes for papers which have been particularly useful and commendable and worthy of grateful acknowledgment.

On recommendation of the Desmond FitzGerald Committee on Awards, the Board voted to present a copy of this book to Richard S. Holmgren for his paper on, "Sewage Disposal Works, Bristol, Rhode Island," presented at a meeting of the Sanitary Section on October 2, 1935, and published in the January, 1936, JOURNAL.

Social Activities

Seven of the regular meetings have been held at the Engineers' Club and one meeting at Chipman Hall, Tremont Temple, preceded by buffet suppers, under the direction of the Social Activities Committee. As usual, the most enthusiastic meeting was student night, held in November, and attended by members of the Student Engineering Societies of Massachusetts Institute of Technology, Harvard, Tufts, Rhode Island State College and Northeastern University Section of the Boston Society of Civil Engineers, at which time representatives of the musical clubs of the latter school assisted in the entertainment. An excursion was made to the new Salem and Beverly Water Treatment Plant at Lake Wenham, Beverly, on June 22, 1935, followed by an outing at Salem Willows, and an excursion to the plant of the American Steel and Wire Company at Worcester on October 16, 1935.

Library

The Report of the Committee on Library contains a complete account of the library activities during the past year.

Society Activities

The usual special committees dealing with the general activities and conduct of the Society have included the following: Program, Publication, Library and Social Activities. Other special committees have included the following: Subsoils of Boston, Run-off, Registration and Licensing of Engineers, Relation of Sections to the Main Society, Desmond FitzGerald and other prizes and John R. Freeman Fund and Welfare Com-

mittee. Each of these committees has made a distinct contribution to the Society and has developed fields of endeavor which will prove of great benefit to the members.

The Society has co-operated with the Engineering Societies of New England, and many members of the Society have served on Engineering Societies' committees.

Your Board, in conclusion, wishes to express its appreciation of the excellent work done by the officers of the Sections and by the committees of the Society.

JOHN B. BABCOCK, *President*.

Report of the Treasurer

BOSTON, March 10, 1936.

To the Boston Society of Civil Engineers:

The finances of the Society are set forth in two appended tables: Table 1, showing the distribution of its funds, receipts and expenditures; and Table 2, recording its investments and the income therefrom.

About 60 per cent of the income from the Permanent Fund was transferred to the Current Fund. The following is a brief statement of current expenditures, and shows the extent to which it has been necessary to use the income of the Permanent Fund to meet them over a period of years:

	1931-32	1932-33	1933-34	1934-35	1935-36
Net expenditures (except such as provided for by appropriations from other than Permanent Fund income)	\$10,086	\$8,734	\$7,228	\$7,609	\$6,333
Members' dues received	7,045	6,030	5,540	5,390	5,115
Deficit	\$3,041	\$2,704	\$1,688	\$2,219	\$1,218

By action of the Board of Government, all securities are carried on the books at their cost, and in a single pool; and all interest, dividends, profit and loss are allocated annually to the Society's various funds, except the Current Fund, on the basis of their book values at the beginning of the fiscal year. During the last year, interest and dividends averaged 4.51 per cent and totaled \$3,848.

Recent changes in the value of the Society's two principal funds are as follows:

	March 10, 1932	March 10, 1933	March 10, 1934	March 10, 1935	March 10, 1936
Permanent Fund:					
Book value	\$50,081	\$50,263	\$50,348	\$51,932	\$52,695
Market value	46,488	42,937	46,029	46,891	99.87%
John R. Freeman Fund:					
Book value	26,722	26,200	26,902	26,999	\$27,359
Market value	23,278	17,667	17,759	16,503	99.87%

The total book value of all holdings is \$87,854.68, not including the value of the library and furniture, which has been carried on the books for the last nineteen years at \$9,905.11.

Respectfully submitted,

KARL R. KENNISON, *Treasurer.*

TABLE 1. — DISTRIBUTION OF FUNDS — RECEIPTS AND EXPENDITURES

	Book Value March 10, 1935	Interest and Dividends	Net Profit (or Loss) at Sale or Maturity	TRANSFER OF FUNDS		Book Value March 10, 1936
				Purchased	Sold	
Bonds	\$25,665 04	\$1,224 72	\$301 70	\$16,965 97	\$4,204 20	\$38,728 51
Co-operative banks	13,526 80	564 22	—	2,375 00	4,000 00	11,901 80
Savings banks	8,997 49	271 91	—	271 91	9,269 40	—
Stocks	37,227 69	1,787 02	-1,118 11	3,272 00	4,252 56	35,129 02
Cash (except Current Fund)	-158 99	—	—	Net increase 754 34	—	595 35
Total (except Current Fund)	\$85,258 03	\$3,847 87	-\$816 41	\$23,639 22	\$21,726 16	\$86,354 68

	Book Value March 10, 1935	ALLOCATION OF THE ABOVE —		Miscellaneous Receipts	Miscellaneous Expenditures	Book Value March 10, 1936
		At 4.513%	At 0.958%			
Permanent Fund	\$51,932 42	\$2,343 81	-\$497 29	\$306 00*	\$1,390 12†	\$52,694 82
John R. Freeman Fund	26,999 26	1,218 54	-258 54	—	600 00†	27,359 26
Edmund K. Turner Fund	1,000 00	45 13	-9 58	—	35 55§	1,000 00
Desmond FitzGerald Fund	2,117 16	95 55	-20 27	—	100 00	2,092 44
Alexis H. French Fund	1,065 55	48 09	-10 20	—	103 44¶	1,000 00
Clemens Herschel Fund	1,099 57	49 63	-10 53	—	11 70**	1,126 97
Edward W. Howe Fund	1,044 07	47 12	-10 00	—	—	1,081 19
Current Fund	\$85,258 03	\$3,847 87	-\$816 41	\$306 00	\$2,240 81	\$86,354 68
	1,327 86	—	—	8,466 26††	8,294 12	1,500 00
Total, all funds	\$86,585 89	\$3,847 87	-\$816 41	\$8,772 26††	\$10,534 93††	\$87,854 68

* Entrance Fees.

† Traveling scholarship.

§ Books.

|| Northeastern University scholarship.

** Prizes.

†† Includes transfer from Permanent Fund to Current Fund.

¶ Books, periodicals and binding.

TABLE 2. — RECORD OF INVESTMENTS.

	Date of Maturity or Classification	Fixed or Current Interest Rate	DURING THE YEAR MARCH 10, 1935, TO MARCH 10, 1936				MARCH 10, 1936		
			Interest or Dividends received	Additional Amount Invested	SOLD OR MATURED		Par Value or Number of Shares	Book Value	Market Value
					Amount received	Profit (or Loss)			
Bonds									
Alabama Water Service Co.	Jan. 1, 1957	5 %	\$13 33	\$1,915 00	—	—	\$2,000	\$1,915 00	\$1,950 00
American Tel. & Tel. Co.	Dec. 1, 1946	5 %	95 00	—	\$2,174 20	\$186 70	—	—	—
Arkansas Water Co.	Oct. 1, 1956	5 %	50 00	—	—	—	1,000	1,005 00	997 50
The Boston Terminal Co.	July 1, 1950	4 %	40 00	—	—	—	1,000	1,000 00	1,040 00
California Water Service Co.	Apr. 1, 1958	5 %	50 00	—	—	—	1,000	972 78	1,055 00
Central Maine Power Co.	Oct. 1, 1960	4 %	-25 78	2,035 36	—	—	2,000	2,035 36	2,060 00
Central Power & Light Co.	Aug. 1, 1956	5 %	50 00	—	—	—	1,000	1,005 00	847 50
Chicago & Northwestern Ry. Co.	Nov. 1, 1987	5 %	25 00	—	—	—	1,000	1,102 50	500 00
The Cleveland Union Term. Co.	Apr. 1, 1973	5 %	-5 97	998 75	—	—	1,000	998 75	1,055 00
The Cleveland Union Term. Co.	Oct. 1, 1977	4½ %	-14 63	980 00	—	—	1,000	980 00	1,007 50
Consolidated Gas Co. of N. Y.	June 1, 1951	4½ %	90 00	—	—	—	2,000	2,000 36	2,145 00
Cons. Water Co. of Utica, N. Y.	May 1, 1958	4½ %	-4 63	3,037 50	—	—	3,000	3,037 50	2,985 00
Houston Lighting & Power Co.	June 1, 1981	4½ %	45 00	—	—	—	1,000	980 28	1,062 50
Illinois Power & Light Corp.	Dec. 1, 1956	5 %	50 00	—	—	—	1,000	981 25	995 00
Kansas Power & Light Co.	Feb. 1, 1947	6 %	60 00	—	1,000 00	85 00	—	—	—
Louisiana Power & Light Co.	Dec. 1, 1957	5 %	50 00	—	—	—	1,000	835 00	1,046 25
Mississippi Power & Light Co.	Dec. 1, 1957	5 %	50 00	—	—	—	1,000	972 50	917 50
The New Rochelle Water Co.	Nov. 1, 1951	5½ %	55 00	—	—	—	1,000	945 00	955 00
Pacific Gas & Electric Co.	June 1, 1960	4½ %	45 00	—	—	—	1,000	1,000 00	1,056 25
Pennsylvania Power & Light Co.	Apr. 1, 1981	4½ %	90 00	—	—	—	2,000	1,927 63	2,145 00
The Pennsylvania Railroad Co.	June 1, 1965	4½ %	45 00	—	—	—	1,000	1,017 74	1,135 00
The Pennsylvania Railroad Co.	Apr. 1, 1970	4½ %	-5 13	971 58	—	—	1,000	971 58	1,032 50
Penn. State Water Corp.	Mar. 1, 1952	5½ %	25 36	2,040 00	—	—	2,000	2,040 00	2,025 00
Peoria Water Works Co.	Aug. 1, 1950	5 %	56	1,010 00	—	—	1,000	1,010 00	1,010 00
Public Electric Light Co.	Oct. 1, 1956	5½ %	110 00	—	—	—	2,000	1,975 00	2,000 00

TABLE 2. — RECORD OF INVESTMENTS — *Concluded*

	Date of Maturity or Classification	Fixed or Current Interest Rate	DURING THE YEAR MARCH 10, 1935, TO MARCH 10, 1936				MARCH 10, 1936		
			Interest or Dividends received	Additional Amount Invested	SOLD OR MATURED		Par Value or Number of Shares	Book Value	Market Value
					Amount received	Profit (or Loss)			
Southern Pacific Co.	Mar. 1, 1977	4½%	\$45 00	—	—	—	\$1,000	\$955 00	\$977 50
Southwestern Gas & Elec. Co.	Nov. 1, 1960	4 %	— 7 44	\$995 00	—	—	1,000	995 00	1,022 50
Southwestern Gas & Elec. Co.	Jan. 1, 1957	5 %	53 61	—	\$1,030 00	\$30 00	—	—	—
Tennessee Public Service Co.	Oct. 1, 1970	5 %	50 00	—	—	—	1,000	1,002 50	790 00
Texas Electric Service Co.	July 1, 1960	5 %	13 33	2,000 00	—	—	2,000	2,000 00	2,080 00
The Toledo Edison Co.	Nov. 1, 1962	5 %	100 00	—	—	—	2,000	2,085 00	2,155 00
Western Maryland R.R. Co.	Oct. 1, 1952	4 %	— 12 89	982 78	—	—	1,000	982 78	1,010 00
Total bonds	—	—	\$1,224 72	\$16,965 97	\$4,204 20	\$301 70	—	\$38,728 51	\$39,057 50
Co-operative Banks									
Merchants Co-operative Bank	Ser. 140, '40	3½%	\$158 27	\$1,712 80	—	—	40	\$4,688 80	\$4,688 80
Suffolk Co-operative Bank	Ser. 134, '40	4 %	46 20	176 20	—	—	10	1,260 00	1,260 00
Suffolk Co-operative Bank	Mat. Shrs.	3 %	33 75	—	—	—	5	1,000 00	1,000 00
Volunteer Co-operative Bank	Ser. 135, '36	4 %	186 00	486 00	—	—	25	4,953 00	4,953 00
Volunteer Co-operative Bank	Mat. Shrs.	—	70 00	—	\$2,000 00	—	—	—	—
Watertown Co-operative Bank	Mat. Shrs.	—	70 00	—	2,000 00	—	—	—	—
Total co-operative banks	—	—	\$564 22	\$2,375 00	\$4,000 00	—	—	\$11,901 80	\$11,901 80
Savings Banks									
Boston Five Cents Savings Bank	—	—	\$29 38	\$29 38	\$1,090 74	—	—	—	—
Charlestown Five Cents Savings Bank	—	—	35 09	35 09	1,106 93	—	—	—	—
Eliot Savings Bank	—	—	111 04	111 04	3,785 69	—	—	—	—
Lynn Five Cents Savings Bank	—	—	96 40	96 40	3,286 04	—	—	—	—
Total, savings banks	—	—	\$271 91	\$271 91	\$9,269 40	—	—	—	—

ANNUAL REPORTS

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Stocks		Cum. Pref. 7%	\$7 00	\$70 00	-	\$705 70	-	\$1,234 30	10	\$980 00	\$730 00
Alabama Power Co.	Pref.	-	-	-	-	-	-	-	-	-	-
American Superpower Corp.	-	9 00	414 00	-	-	-	-	-	46	5,346 04	7,843 00
American Tel. & Tel. Co.	-	2 00	5 00	-	-	-	-	-	10	640 00	640 00
Bankers Trust Co.	-	7 00	87 50	-	-	-	-	-	10	1,020 00	935 00
Carolina Power & Light Co.	Cum. Pref. 7%	3 00	24 00	-	-	-	-	-	8	504 00	504 00
Commonwealth & Southern Corp.	Cum. Pref.	-	-	-	-	-	-	-	25	1,019 89	78 12
Commonwealth & Southern Corp.	Opt. Warrants	-	-	-	-	-	-	-	12	-	4 50
Consolidated Gas Co. of N. Y.	Common	1 00	20 00	-	-	-	-	-	20	1,906 50	690 00
Consumers Power Co.	Cum. Pref. 6%	6 00	60 00	-	-	-	-	-	10	1,020 00	1,060 00
Electric Power & Light Corp.	Cum. Pref. 7%	-	-	-	-	272 34	-	-740 11	10	-	-
Electric Power & Light Corp.	Common	-	-	-	-	-	-	-	10	63 75	121 25
General Electric Co.	-	1 00	14 00	-	-	-	-	-	20	769 53	797 50
Georgia Power Co.	Cum. Pref.	6 00	84 00	-	-	-	-	-	14	1,143 33	1,190 00
Minnesota Power & Light Co.	Pref. 7%	7 00	61 20	-	-	-	-	-	10	980 00	925 00
Mississippi River Power Co.	Cum. Pref.	-	45 00	-	-	1,064 10	164 10	-	-	-	-
Montreal Lgt., Ht. & Po., Cons.	Common	-	68 84	-	-	2,189 88	692 20	-	-	-	-
New England Power Assoc.	Pref.	4 00	80 00	-	-	-	-	-	20	1,815 00	1,440 00
New York Central R.R. Co.	Pref.	6 00	60 00	-	-	-	-	-	10	960 00	1,220 00
North American Trust Shares	-	-	-	-	-	-	-	-	1,000	3,397 00	3,250 00
Northwestern Electric Co.	Cum. June 30, '55	112	20 80	2,632 00	-	-	-	-	10	980 00	700 00
Pacific Gas & Electric Co.	Cum. 1st Pref.	1 50	90 00	-	-	-	-	-	60	1,830 00	1,830 00
Pacific Gas & Electric Co.	1st Pref. 5½%	1 376	27 52	-	-	-	-	-	20	1,922 02	545 00
Pacific Gas & Electric Co.	Common	1 50	96 00	-	-	-	-	-	64	1,808 79	2,216 00
Penn. Gas & Elec. Corp.	Pref.	7 00	210 00	-	-	-	-	-	30	2,955 00	2,550 00
Radio Corp. of America	Common	-	-	-	-	20 54	-	-	-	-	-
Southern Cal. Edison Co., Ltd.	Cum. Orig. Pref.	1 50	67 50	-	-	-	-	-	40	1,161 22	1,400 00
Southern Cal. Edison Co., Ltd.	Common	1 50	30 00	-	-	-	-	-	20	539 75	510 00
The Tenn. Elec. Power Co.	1st Pref. 7%	7 00	70 00	-	-	-	-	-	10	950 00	730 00
Trimount Dredging Corp.	Pref. C	-	-	-	-	-	-	-	2	-	-
United States Steel Co.	Common	-	-	-	-	-	-	-	10	860 75	650 00
Utah Power & Light Co.	Cum. Pref. 7%	2 332	11 66	-	-	-	-	-	10	990 00	570 00
West Penn Power Co.	Cum. Pref. 7%	7 00	70 00	-	-	-	-	-	10	1,030 00	1,195 00
Total, stocks	-	-	\$1,787 02	\$3,272 00	\$4,252 56	-	-\$1,118 11	-	-	\$35,129 02	\$34,690 62

Report of the Secretary

BOSTON, March 10, 1936.

To the Boston Society of Civil Engineers:

The following is a statement of cash received by the Secretary, and of the expenditures approved by the President, in accordance with the budget adopted by the Board of Government for the year ending March 18, 1936:

	CURRENT FUND ACCOUNT		Cash Receipts	Credit Transfers by Treasurer	NET DISTRIBUTION UNDER BUDGET	
	Account Number	Expenditures			Expenditures	Receipts
Office:						
Secretary — salary and expense.	(1)	\$240 00	—	—	—	—
Stationery, printing and postage	(2)	329 54	—	—	—	—
Incidentals and petty cash	(3)	105 12	—	—	—	—
Insurance and Treasurer's bond	(4)	43 63	—	—	—	—
Safety deposit box	(5)	11 00	—	—	—	—
Prizes	(6)	11 70	—	\$11 70*	—	—
Quarters, rent, light, telephone	(7)	1,745 85	\$682 50†	—	—	—
Office, clerical	(8)	1,440 00	—	—	—	—
Auditors for 1935 accounts	(9)	75 00	—	—	—	—
Total		\$4,001 84	\$682 50	\$11 70	\$3,307 64	—
Meetings:						
Rent of halls, etc.	(11)	\$226 20	—	—	—	—
Stationery, printing and postage	(12)	114 12	—	—	—	—
Social activities	(13)	114 38	—	—	—	—
Stereopticon	(15)	9 75	—	—	—	—
Annual meeting (March, 1935)	(16)	87 10	—	—	—	—
Total		\$551 55	—	—	\$551 55	—

	CURRENT FUND ACCOUNT		Cash Receipts	Credit Transfers by Treasurer	NET DISTRIBUTION UNDER BUDGET	
	Account Number	Expenditures			Expenditures	Receipts
Engineering Societies of New England	(59)	\$764 90	—	—	\$764 90	—
Dues from members	(70)	—	\$5,114 57	—	—	\$5,114 57
Secretary's bank balance as of March 20, 1935		—	105 40	—	—	105 40
Income from Permanent Fund		—	—	\$1,390 12	—	1,390 12
Total Current Fund		\$8,444 81	\$7,076 14	\$1,540 81	\$6,456 78	\$6,628 92
Entrance fees: 14 new members, 5 juniors and 27 students; 7 juniors and 1 student transferred to members, and 4 students transferred to junior		—	\$306 00	—	—	\$306 00

The above cash receipts have been paid to the Treasurer, whose receipt the Secretary holds.

Respectfully submitted,

EVERETT N. HUTCHINS, *Secretary*.

Report of the Auditing Committee

BOSTON, March 17, 1936.

We have examined the records and accounts of the Secretary and the Treasurer of the Boston Society of Civil Engineers and have satisfied ourselves that these have been properly kept and that funds received and expended have been duly recorded. We have examined the securities enumerated by the Treasurer and verified the income from investments. In this examination your committee has been assisted by William J. Hyde, Certified Public Accountant.

The signed reports of the Secretary and of the Treasurer, to which this statement is attached, are properly reconciled, summarize the transactions and indicate the actual financial condition of the Society.

J. STUART CRANDALL,
ALBERT HAERTLEIN,
*Auditing Committee of the Directors of the
Boston Society of Civil Engineers.*

STATEMENT OF THE CERTIFIED PUBLIC ACCOUNTANT

MARCH 17, 1936.

*Auditing Committee, Boston Society of Civil Engineers, Room 715, Tremont Temple,
Boston, Massachusetts:*

GENTLEMEN. — In accordance with your instructions, I have completed an audit of the financial records of the Society for the fiscal year ended March 10, 1936.

Securities held by the Society as at March 10, 1936, were examined and correctly reflected the changes occurring within the year under review. All coupons for interest due were collected, except that of the Chicago & Northwestern Railway Company, due November 1, 1935, for \$25, which is in default. Dividends earned were verified and all were correctly accounted for. The records of purchases and sales of securities were in agreement with brokers' statements.

Receipts reported as coming from your Secretary were compared with his records and found to be correctly entered in the Treasurer's accounts.

Savings bank interest and co-operative bank earnings were verified and found correct.

All vouchers paid were approved by your President and payment substantiated by examination of cancelled checks.

A verified copy of your Treasurer's report is attached hereto, and summarizes the detailed records of his ledger, which I have carefully checked and found in excellent condition.

Respectfully submitted,

WM. J. HYDE,
Certified Public Accountant.

Report of the Editor

BOSTON, MASS., February 15, 1936.

To the Board of Government, Boston Society of Civil Engineers:

The JOURNAL for the calendar year 1935 (Volume XXII) was issued quarterly, in the months of January, April, July and October, as authorized by the Board of Government on December 20, 1935.

During the year 1935 there have been published eleven papers, presented at meetings of the Society and Sections, and two other technical articles. The Contents and Index for the year 1934 are included in the January, 1935, issue, and for the year 1935 in the October issue.

The four issues of the JOURNAL contained 286 pages of papers and discussions, 13 pages of index, and 24 pages of advertising, a total of 323 pages. An average of 1,237 copies per issue were printed. The net cost was \$2,091.41, as compared with \$2,081.37 for the preceding year.

Table I includes a comparison of the costs for the JOURNAL from 1931-35, inclusive. In Table II details of cost for Volume XXII of the JOURNAL for the calendar year 1935 are shown.

Respectfully submitted,

EVERETT N. HUTCHINS, *Editor*.

TABLE I. — COMPARISON OF COSTS OF JOURNAL, 1931-35, INCLUSIVE

YEAR	Volume	Number of Pages*	Gross Total†	Cost per Page	Net Total‡	Cost per Page	Number of Cuts and Inserts
1931 . . .	XVIII	515	\$3,916 95	\$7 60	\$2,634 18	\$5 11	99
1932 . . .	XIX	633	3,906 87	6 17	2,600 62	4 10	108
1933 . . .	XX	331	2,265 51	6 84	1,389 36	4 17	82
1934 . . .	XXI	383	2,966 67	7 74	2,081 37	5 43	126
1935 . . .	XXII	323	2,628 16	8 13	2,091 41	6 47	119

* Includes Advertising Section and Annual Index.

† Gross cost included editing, printing and mailing.

‡ Net cost equals gross less amounts received for advertising, subscriptions and sale of JOURNALS.

TABLE II. — 1935 JOURNAL, VOLUME XXII

	ISSUES OF —				
	January	April	July	October	Total
Number of pages:					
Papers and discussion	73*	84	72	70†	299
Advertising and advertisers' index	6	6	6	6	24
Total pages	—	—	—	—	323
Number of cuts	31	36	26	26	119
<i>Cost of Journal</i>					
Composition and printing	\$379 08	\$534 82	\$357 52	\$370 49	\$1,641 91
Cuts	144 23	171 50	123 38	119 85	558 96
Wrapping, mailing and postage	—	—	—	—	119 29
Editing	—	—	—	—	300 00
Copyright	—	—	—	—	8 00
Total gross cost of JOURNAL	—	—	—	—	\$2,628 16
Receipts from subscriptions and sales of JOURNALS and reprints	\$213 70				
Receipts (net) from advertising	322 05				
Total receipts					535 75
Net cost of JOURNAL					\$2,092 41

* Includes 7 pages of Index of 1934 JOURNAL.

† Includes 6 pages of Index of 1935 JOURNAL.

Report of the Committee on Social Activities

BOSTON, March 18, 1936.

To the Boston Society of Civil Engineers:

The Committee on Social Activities submits the following report for the year 1935-36.

At the seven regular meetings at the Engineers' Club, held during the past year, an average of 67 members and guests per meeting were served with buffet suppers. This average is 10 greater than for the previous year. The smallest number served was 35 and the largest 83. There were on the average 27 additional persons at the meetings following the supper.

Eighty-six members and guests attended the annual dinner at the Chamber of Commerce Building.

Seventy members and guests made the excursion to the new Salem-Beverly Water Treatment Plant at Wenham Lake on Saturday, June 22, 1935, and 45 attended the outing and dinner which followed at "Ebsen's" at Salem Willows. This excursion included ladies.

On October 16, 1935, an excursion was made to the American Steel and Wire Company plant at Worcester, prior to the regular evening meeting.

One hundred and forty-five were served at the November meeting, which was designated as Student Night and which included the Student Chapters of the American Society of Civil Engineers at Harvard, Massachusetts Institute of Technology, Tufts, and the Northeastern University Section of the Boston Society of Civil Engineers.

The charge for buffet suppers has been 50 cents, the same as during the past year.

It is gratifying to note that there has been a larger attendance than for some time past at the last three regular meetings. We sincerely hope that this attendance will continue to increase.

Respectfully submitted,

JOHN H. HARDING, *Chairman.*

Report of the Committee on Relation of Sections to the Main Society

MARCH 14, 1936.

To the Boston Society of Civil Engineers:

The Committee on Relation of Sections to the Main Society, made up of the four Section chairmen together with a member representing the main Society, has held no formal meetings during the past year. Its work consisted largely in arranging joint meetings at the Sections whenever the program was of special interest to more than one Section.

The method of announcing notices of meetings in the weekly Journal of the Engineering Societies of New England has frequently brought to the meetings of a Section members of the Society who are not enrolled in the Section. This broadens the value of the Section and is to be encouraged. Since the expenses of a Section are no longer dependent on the number of individual notices to be mailed, it is suggested that the whole of the Society's membership be automatically considered as the membership of each Section, with the exception of the Northeastern University Section. The latter is composed of students at Northeastern University. Such a procedure would simplify the nomination of candidates for the officers of the Section. At present it frequently happens that a member of the Society is nominated for an office on account of the interest he has shown at the meetings of the Section, only to find that he is not on the official list as a member of the Section. If this recommendation is adopted, it would relieve the Section of the necessity of maintaining a meaningless membership list.

The stated meetings of the Highway Section on the third Wednesday in September and the fourth Wednesday in November are unfortunate. The first because it is

somewhat early in the season, and the latter because it usually occurs on the evening before Thanksgiving Day. The Section is attempting to set other dates for these meetings which will not interfere with the other Sections.

Respectfully submitted,

For the Committee,

ALBERT HAERTLEIN, *Chairman.*

Report of the Committee on Welfare

MARCH 18, 1936.

To the Boston Society of Civil Engineers:

The Committee on Welfare has not found it necessary to hold any meetings or to take action on any matters relative to the welfare of our members during the past year, thanks to the activities of the Emergency Planning and Research Bureau, Inc. The activities of the Bureau are devoted to the welfare of all unemployed who have been connected with engineering work in this locality, whether they are members of an engineering society or not.

During the past year the Bureau has spent its efforts toward placing engineering employees on the pay rolls of others rather than to employ them on its own pay roll. This has been accomplished through sponsorship, by the Bureau, of several Federal relief projects affording engineering work for Bureau employees and registrants, and by the activities of the employment service of the Bureau.

It is hoped that the Bureau's employment service will be the focal point of all engineering employment activities in this locality. This employment service is available without charge to all, being financed by funds of the Bureau, but registration with the Bureau's employment service is in no sense an application for charity or relief.

A summary of the employment activities of the Bureau during the year 1935, indicating the assistance afforded members of the Boston Society of Civil Engineers, is shown by the following tabulation:

Emergency Planning and Research Bureau, Inc., 1935

Unemployed engineers registered at Bureau during year	320
Positions secured through Bureau during year	329
Individuals employed at Bureau during year	61
Members of Boston Society of Civil Engineers registered at Bureau during year	19
Members of Boston Society of Civil Engineers employed by Bureau during year	1
Positions secured for members of Boston Society of Civil Engineers through Bureau during year	35

Respectfully submitted,

RALPH W. HORNE, *Chairman.*

Report of the Library Committee

BOSTON, March 18, 1936.

To the Boston Society of Civil Engineers:

During the year the Committee had six meetings at which the following things were discussed:

1. Measures for avoiding further loss of books from the library.
2. Disposal of old books, reports and magazines to make room for new publications.
3. Purchase of new books.

The binding of periodicals was brought nearly up to date, and it is estimated that an additional sum of \$90 will entirely complete this work.

The geological maps have been rearranged to the present fiscal year.

Our records show that during the year one hundred and twenty books were loaned to members, and that fines collected amounted to \$5.72. Also, sale of magazines amounted to \$5.

The committee wishes to thank our President, Prof. J. B. Babcock, 3d, for his foresight and effort which made possible the appropriation of money that enabled the committee to resume the purchase of recent textbooks, which it is believed will be of value to the membership at large. Attached to this report is a complete list of the books purchased and added to the Library during the year.

In the future all new books will be loaned for a period of only seven days instead of fourteen days.

We respectfully recommend the disposal of out-of-State reports as stated in our letter of February, 1936, to the Board of Government.

Respectfully submitted,

ARTHUR J. HARTY, *Chairman.*

ADDITIONS TO THE LIBRARY

Activities of the Bureau of Yards and Docks. Government Publication.
 Advanced Mechanics of Materials. F. B. Seely.
 American Institute of Steel Construction.
 American Sewerage Practice, Vol. 3. (Gift of Metcalf & Eddy.)
 Arc-Welded Steel Frame Structures. G. D. Fish.
 Building the Emergency Fleet. W. C. Mattox.
 Civil Engineering Handbook. Urquhart. (Gift of J. B. Babcock, 3d.)
 Continuous Frames of Reinforced Concrete. Cross and Morgan.
 Elementary Surveying, Vol. 1. Breed and Hosmer.
 Elements of Specification Writing. R. S. Kirby.
 Elements of Water Supply Engineering. E. L. Waterman.
 Elimination of Taste and Odor in Water. John R. Baylis.
 Forms and Centering. A. B. MacMillan.
 Heating and Air Conditioning. Allen and Walker.
 High Surveying and Planning. T. F. Hickerson.

- Higher Surveying, Vol. 2. Breed and Hosmer.
 Highway Bridges, Design and Cost. J. E. Kirkham.
 Highway Design and Construction. A. G. Bruce.
 History of the Water Supply of the World. T. J. Bell.
 Leveling in Maine. C. J. Clifford, United States Department of Commerce, Washington, D. C.
 Leveling in Massachusetts, Rhode Island and Connecticut. C. J. Clifford, United States Department of Commerce, Washington, D. C.
 Leveling in New Hampshire and Vermont. C. J. Clifford, United States Department of Commerce, Washington, D. C.
 Mechanical Vibrations. J. P. DenHartog.
 Merrimack River, its Source and Tributaries. J. W. Meader.
 North Shore Improvement Association. (Gift of Andrew D. Fuller.)
 Open Door at Home. C. A. Beard. (Gift of Aberthaw Construction Company.)
 Power Supply Economics. J. D. Justin and W. G. Mervine.
 Report on Mosquitoes.
 Resistance of Materials. F. B. Seely.
 Safety and Economy in Heavy Construction. R. J. Reigeluth.
 Standard Construction Methods. G. Underwood.
 Standard Specifications for Highway Bridges. (Adopted by American Association of State Highway Officials, Washington, D. C.)
 Suspension Bridges of Short Span. F. H. Frankland.
 Water Supply of England and Wales. C. E. DeRance.
 Work of the Sanitary Engineer. A. J. Martin. (Gift of Aberthaw Construction Company.)

Reports

- Local Control Survey.
 Maine Piling Investigation (Boston & Maine Railroad, Boston, Mass.).
 Massachusetts Highway Accident Survey.
 Real Property Inventory, Vols. 1 and 2.
 Stream Gaging Stations in Massachusetts.
 Tentative and Preliminary Plan for New England.

Report of the Committee on John R. Freeman Scholarship Fund

BOSTON, March 16, 1936.

To the Boston Society of Civil Engineers:

On June 12, 1934, the John R. Freeman Scholarship Fund Committee notified Mr. Everett N. Hutchins, Secretary, that it had awarded the scholarship for the year 1934-35 to Prof. Leslie J. Hooper of the Worcester Polytechnic Institute.

The special work to be done by Professor Hooper was to make a study of and report on the hydraulic laboratories in this country.

A report was made by Professor Hooper April 19, 1935, covering the results of his trip and investigation up to that date, covering visits to five college hydraulic laboratories and seven commercial laboratories, all in the eastern part of the country.

From April 20 to July 30, 1935, about eighteen college laboratories, seven company testing plants and a few power plants were visited.

A great deal of hydraulic research was found to be in progress and many interesting investigations were brought to his attention. The report of this trip is about half finished. It is expected that within a few months there will be made one more inspection trip to Vicksburg and other hydraulic laboratories which may be conveniently reached along the way.

Your Committee is unable to say when the final report will be presented. The Treasurer's report will show the financial condition of the fund.

Respectfully submitted,

For Freeman Scholarship Fund Committee,

CHARLES T. MAIN, *Chairman.*

Report of the Executive Committee of the Sanitary Section

BOSTON, March 4, 1936.

To the Sanitary Section, Boston Society of Civil Engineers:

During the past year five meetings have been held as follows, at which the following papers have been given:

May 1, 1935. — "Design and Progress on Construction of Dams for Quabbin Reservoir," by Stanley M. Dore, Assistant Designing Engineer, Metropolitan District Water Supply Commission.

October 2, 1935. — "Sewage Disposal Works, Bristol, Rhode Island," by Richard S. Holmgren, Chief Engineer, New Hampshire Water Resources Board.

November 6, 1935. — "Food Sanitation," by Herman C. Lythgoe, Director, Division of Foods and Drugs, Massachusetts Department of Public Health.

December 4, 1935. — "Sewage Disposal in South Australia," by H. G. N. Hodgson, Division Engineer of Sewerage and Sewage Disposal, Public Works Department, South Australia.

February 5, 1936. — "Sanitary Conditions in Boston Harbor," by Gail P. Edwards, Laboratory Co-ordinator, Engineering Division, Massachusetts Department of Public Health.

Attendance. — Attendance at these meetings varies from 32 to 75, averaging 46.

The annual outing was held in June in co-operation with the main Society. This consisted of a visit to the Salem-Beverly Water Treatment Plant at Wenham Lake, Beverly, followed by a social time and supper at Salem Willows.

Executive Committee meetings have been held prior to every section meeting.

Respectfully submitted,

For the Executive Committee,

RICHARD S. HOLMGREN, *Clerk.*

Report of the Executive Committee of the Designers Section

Boston, March 11, 1936.

To the Designers Section, Boston Society of Civil Engineers:

This Section has held eight regular meetings during the past year, as follows:

March 13, 1935. — Annual meeting, and election of officers, at the Society rooms. *Speaker*, Mr. John R. Nichols, Consulting Engineer, on "A Discussion of the Proposed Building Law for Boston." *Attendance*, 32.

April 10, 1935. — *Speaker*, Mr. Arthur C. Ruge, Research Associate in Seismology, Massachusetts Institute of Technology, on "The Effects of Earthquakes on Elevated Water Tanks as Determined by Model Studies." *Attendance*, 17.

May 8, 1935. — *Speaker*, Mr. E. F. Gallagher of the Brick Manufacturers' Association, on "Reinforced Brick Masonry." *Attendance*, 45.

October 9, 1935. — *Speaker*, Col. Lewis E. Moore, Consulting Engineer, on "Bridge Problems." *Attendance*, 42.

November 13, 1935. — A joint meeting with the Highway Section at Pierce Hall, Harvard University, as guests of the Harvard Graduate School of Engineering. *Speakers*: Prof. Arthur Casagrande, on "Characteristics of Cohesionless Soils Affecting the Stability of Slopes and Earth Fills"; and Mr. P. C. Rutledge of the Harvard Graduate School of Engineering, on "Recent Developments in Soil Testing Apparatus." The meeting included an inspection of the soil mechanics laboratory. *Attendance*, 125.

December 11, 1935. — At Massachusetts Institute of Technology, Cambridge. *Speakers*: Lieut. John B. Elliott, United States Corps of Engineers, and Prof. Kenneth C. Reynolds of Massachusetts Institute of Technology, on "Cape Cod Canal Research." This meeting included an inspection of the model of the Cape Cod Canal. *Attendance*, 120.

January 8, 1936. — *Speaker*, Prof. Albert Haertlein, our Vice-Chairman and Associate Professor of Civil Engineering at the Harvard Graduate School of Engineering, on "The Design of Statically Indeterminate Frames." *Attendance*, 30.

February 26, 1936. — A joint meeting with the Highway Section at the Society rooms. *Speaker*, Albert E. Kleinert of the Massachusetts Department of Public Works, on "The Design and Construction of the Quincy-Weymouth Fore River Bridge." *Attendance*, 60.

The total attendance at all meetings, including joint meetings, was 471, with an average attendance of 59 each meeting.

Membership in the Section in March, 1935, was 169. During the year 3 members have died and 2 have resigned, making the present membership of 164.

Respectfully submitted,

For the Executive Committee,

ANTHONY S. COOMBS, *Clerk*.

Report of Executive Committee of the Highway Section

BOSTON, February 26, 1936.

To the Highway Section, Boston Society of Civil Engineers:

During the past year three meetings were held.

February 13, 1935. — Annual meeting, election of officers. This was a joint meeting with the Designers Section. Two papers were presented: "The New Cambridge-Concord Highway," by F. D. Sabin, District Engineer, Massachusetts Department of Public Works; and "Improvements on the Newburyport Turnpike and Newburyport," by J. E. Lawrence, District Engineer with the Massachusetts Department of Public Works. *Attendance, 85.*

April 24, 1935. — "Massachusetts Highway Accident Survey," by Col. R. C. Eddy of the Massachusetts Institute of Technology. *Attendance, 37.*

November 13, 1935. — Joint meeting with Designers Section. "Characteristics of Cohesionless Soils Affecting the Stability of Slopes and Earth Fills," by Prof. Arthur Casagrande of Harvard Engineering School. *Attendance, 105.*

The average attendance during the year was 76.

During the year one member resigned and there was one death. The present membership is 96.

Respectfully submitted,

For the Executive Committee,

ALEXANDER J. BONE, *Clerk.*

Report of the Executive Committee of the Northeastern University Section

BOSTON, March 10, 1936.

To the Boston Society of Civil Engineers:

During the past year the section has held six meetings, as follows:

March 28, 1935. — "Water Analysis and Purification," by Robert Johnson of Weston & Sampson. *Attendance, 40.*

May 2, 1935. — "Surveying Instruments," by Louis E. Buff of Buff & Buff Manufacturing Company. *Attendance, 36.*

May 23, 1935. — Annual meeting, election of officers. "Model Bridges," by several students who made the various bridge models displayed. *Attendance, 50.*

October 3, 1935. — "The Design and Construction Features of the New Railroad Bridge at Buzzard's Bay," by William H. Bruce of Parsons, Klapp, Brinkerhoff & Douglas, Consulting Engineers. *Attendance, 30.*

December 13, 1935. — "Ground Water Supplies," by Paul F. Howard of Whitman & Howard. *Attendance, 20.*

February 18, 1936. — "Traffic Control Problems," by Maxwell Halsey, Assistant Director of the Bureau for Street Traffic Research, Harvard University. *Attendance, 41.*

Two field trips were conducted as follows:

Worcester Sewage Treatment Works — April 28, 1935, for Division A, and May 21, 1935, for Division B.

New Railroad Bridge at Buzzard's Bay — September 24, 1935, for Division A, and October 22, 1935, for Division B.

The average attendance at meetings was 36.

The average attendance on field trips was 42.

Membership in March, 1935, 77.

New members elected, 20.

Transfer to grade of junior, 2.

Membership at present, 95.

Respectfully submitted,

For the Executive Committee,

FRANCIS J. FLYNN, *Clerk.*

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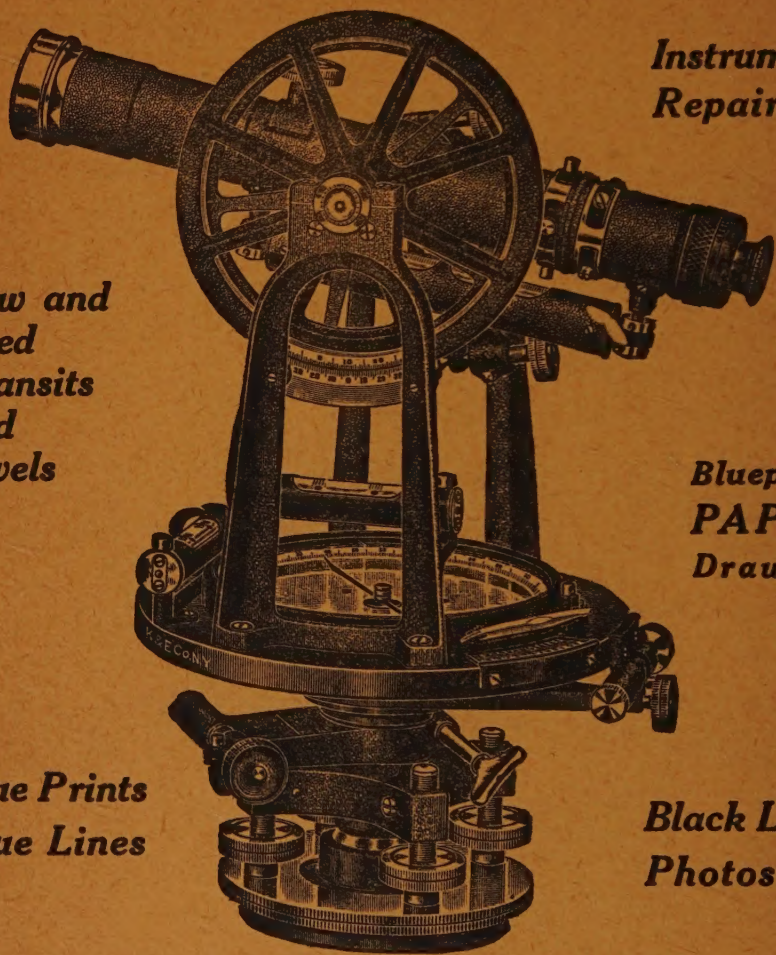
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